BOONTON

BOONTON ELECTRONICS CORPORATION

PRELIMINARY

INSTRUCTION MANUAL

MODEL 9200B
RF MILLIVOLTMETER

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INSTRUCTION MANUAL

MODEL 9200B
RF MILLIVOLTMETER

NOTE

The 9200B Manual is being printed and is not ready. This preliminary manual is enclosed so that the instrument can be shipped without delay. A complete manual will be shipped as soon as it is available.

10-1-86

BOONTON
ELECTRONICS CORPORATION

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TELEPHONE: 201 — 584-1077 TWX: 710-986-8215

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation and maintenance of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Boonton Electronics assumes no liability for the customer's failure to comply with these requirements.

THE INSTRUMENT MUST BE GROUNDED

To minimize shock hazard the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three conductor, three prong a.c. power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to a two-contact adapter with the (green) grounding wire firmly connected to an electrical ground at the power outlet.

DO NOT OPERATE THE INSTRUMENT IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by quailfied maintenance personnel. Do not replace components with the power cable connected. Under certain conditions dangerous voltages may exist even though the power cable was removed, therefore; always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Do not install substitute parts or perform any unauthorized modification of the insturment. Return the instrument to Boonton Electronics for repair to ensure that the safety features are maintained.

SAFETY SYMBOLS.

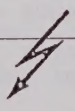
This safety requirement symbol (located on the rear panel) has been adopted by the International Electrotechnical Commission, Document 66 (Central Office) 3, Paragraph 5.3, which directs that and instrument be so labeled if, for the correct use of the instrument, it is necessary to refer to the instruction manual. In this case it is recommended that reference be made to the instruction manual when connecting the instrument to the proper power source. Verify that the correct fuse is installed for the power available, and that the switch on the rear panel is set to the applicable operating voltage.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operation procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the equipment. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

WARNING

The WARNING sign denotes a hazard. It calls attention to an operation procedure, practice, or the like, which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.



Indicates dangerous voltages.

SECTION I

INTRODUCTION

1-1. SCOPE OF MANUAL.

1-2. This instruction manual provides descriptive data, operating instructions, theory of operation, maintenance instructions and a parts list for the Model 9200B RF Voltmeter. (See Figure 1-1.) The instrument is manufactured by Boonton Electronics Corporation, Randolph, New Jersey.

SAFETY NOTICE

Although this instrument has been designed in accordance with international safety standards, general safety precautions must be observed during all phases of operation and maintenance of the instrument. Failure to comply with the precautions listed in the Safety Summary located in the front of this manual could result in serious injury or death. Service and adjustment should be performed only by qualified service personnel.

1-3. PURPOSE OF EQUIPMENT.

1-4. The instrument is microprocessor-based with unique features that make it useful for systems requirements as well as for manual operation. The basic instrument can measure RF voltage levels from 200 microvolts to 3 volts over a frequency range from 10 kHz to 1.2 GHz. An optional Model 952005 100:1 Voltage Divider extends the voltage range to 300 V up to 700 MHz. A 50Ω terminated RF sensor, Model 952009, is also available to measure RF voltage levels from 200 microvolts to 3 volts over a frequency range from 100 kHz to 2.5 GHz. Option 9200B-03 adds a second complete input section that allows the connection of an additional RF probe for simultaneous measurements of two voltage levels.

Measured RF levels can be displayed directly in mV, dBV, dBmV, dBm (dB relative to 1 mW across any impedance between 5Ω and 250Ω) or dBw (dB relative to 1W across any impedance between 20Ω and 2000Ω). Typical uses of the instrument include:

a. Measurement of transistor parameters.

b. SWR and return loss measurements with directional couplers, reflection coefficient bridges and slotted lines.

c. Gain and loss measurements of wide-band amplifiers.

d. Adjustment of tuned circuits in narrow-band amplifiers.

e. Adjustment, performance measurements and parameter evaluation of RF filters.

f. Measurement of SWR, return loss and attenuation of RF attenuators.

g. Measurement of output levels of signal generators, adjustment of baluns, harmonic distortion measurements of RF signals and adjustment of RF circuits for minimum voltage (null) or maximum voltage (peak).

1-5. DESCRIPTION OF EQUIPMENT.

1-6. The instrument is packaged as a compact bench unit with adjustable angle bail. Hardware kits to accommodate either one or two instruments for rack mounting are also available as options. The basic characteristics of the instrument include high reliability, fast warmup, long intervals between calibration, good serviceability and light weight. Incorporation of a microprocessor, together with a stored program memory and a non-volatile memory, result in performance features and operating convenience not previously available in a general purpose RF millivoltmeter. Among the outstanding performance features are:

a. Wide Frequency Range. The calibrated frequency range of the instrument is determined by the probe used with the instrument. The Model 952001 RF Probe supplied with the instrument provides calibrated indications from 10 kHz to 1.2 GHz, with uncalibrated response to beyond 8 GHz. An optional Model 952009 RF Sensor provides calibrated, 50Ω terminated indications from 100 kHz to 2.5 GHz.

NOTE

Sensitivity and range linearization data for the probe supplied with the instrument is stored in non-volatile memory. If another probe is used with the instrument, data for this probe must be entered into non-volatile memory before using the probe. Data entry is a simple procedure, requiring only operation of an internal switch and entry of data through the front-panel keys. No further calibration is necessary.

b. Wide Measurement Range. The instrument has eight voltage measurement ranges from 1 mV to 3 volts full scale, arranged in a 1-3-10 sequence. In the dB measurement modes, it covers a range of 80 dB in 8 ranges, with 0.01 dB resolution. The measurement capability of the instrument can be extended to 300 volts at frequencies up to 700 MHz through use of the optional Model 952005 100:1 Voltage Divider.

952458 →

c. True RMS Response. Waveform response of the instrument probe is true RMS for inputs below 30 mV, allowing accurate voltage measurements with all types of waveforms. Probe waveform response changes gradually as the input voltage is raised above 30 mV approaching peak-to-peak at the higher levels. The instrument shapes the response digitally to indicate RMS voltage, provided that the input is reasonably sinusoidal, as with CW or FM input signals.

d. Low Noise. The instrument has been designed and constructed to minimize noise from all sources. The probe cable is of a special low noise design; vigorous flexing causes only momentary, minor deflections on the most sensitive range of the instrument. The probes are insensitive to shock and vibration; even sharp tapping on the probe barrel causes no visible deflection on any range. Internal signal amplification occurs at approximately 94 Hz, thereby reducing susceptibility to 50 or 60 Hz fields. A low noise solid-state chopper is used.

e. Key Selection of Measurement Modes. A choice of measurement modes is available to the operator. Measurements in terms of mV, dBV, dBmV, dBm (dB relative to 1 mW across any impedance between 5 and 2506Ω) or dBw (dB relative to 1W across any impedance between 520Ω and 2000Ω) can be selected by merely pressing the appropriate front-panel key. The keyboard also allows entry of dB reference levels and impedance values for these measurement modes.

f. Display. Measured values are displayed on a 4 digit, LED type readout with decimal points and minus sign. Annunciators associated with the display indicate the units of measurement. The result is clear, direct, unambiguous readout that minimizes the possibility of misinterpretation. The display is also used to show data being entered into non-volatile memory and to display data recalled from non-volatile memory; the display and annunciators blink on and off during data entry and recall to indicate that displayed values are not measured values.

g. Analog Indications. A front-panel meter provides relative RF level indications for peaking or nulling applications. A rear panel DC output supplies 10 volts full scale that is linear with voltage in the mV mode, or linear in dB over the entire 80 dB range in any of the dB modes.

h. Automatic Ranging. Autoranging under control of the microprocessor eliminates the need for manual ranging by the operator. Alternately, a measurement range can be retained for measurements, if desired, by selecting a range hold mode through the IEEE-488 Bus when the instrument is so equipped. Application of input levels beyond the measurement capability of the instrument in the autorange mode or outside the selected range in the range hold mode results in an error indication on the display.

i. Automatic Zeroing. An automatic zeroing circuit eliminates the need for tedious, often inaccurate manual zeroing. With zero input to the probe, pressing the front-panel ZERO key causes the microprocessor to compute and store zero corrections for each range, which are applied to subsequent readings. A logic transition is available at a rear panel connector for automatic turn off of a source during the automatic zeroing sequence.

j. Stored Probe Data. Sensitivity and range linearization data for up to eight probes may be stored in the instrument non-volatile memory. Probe

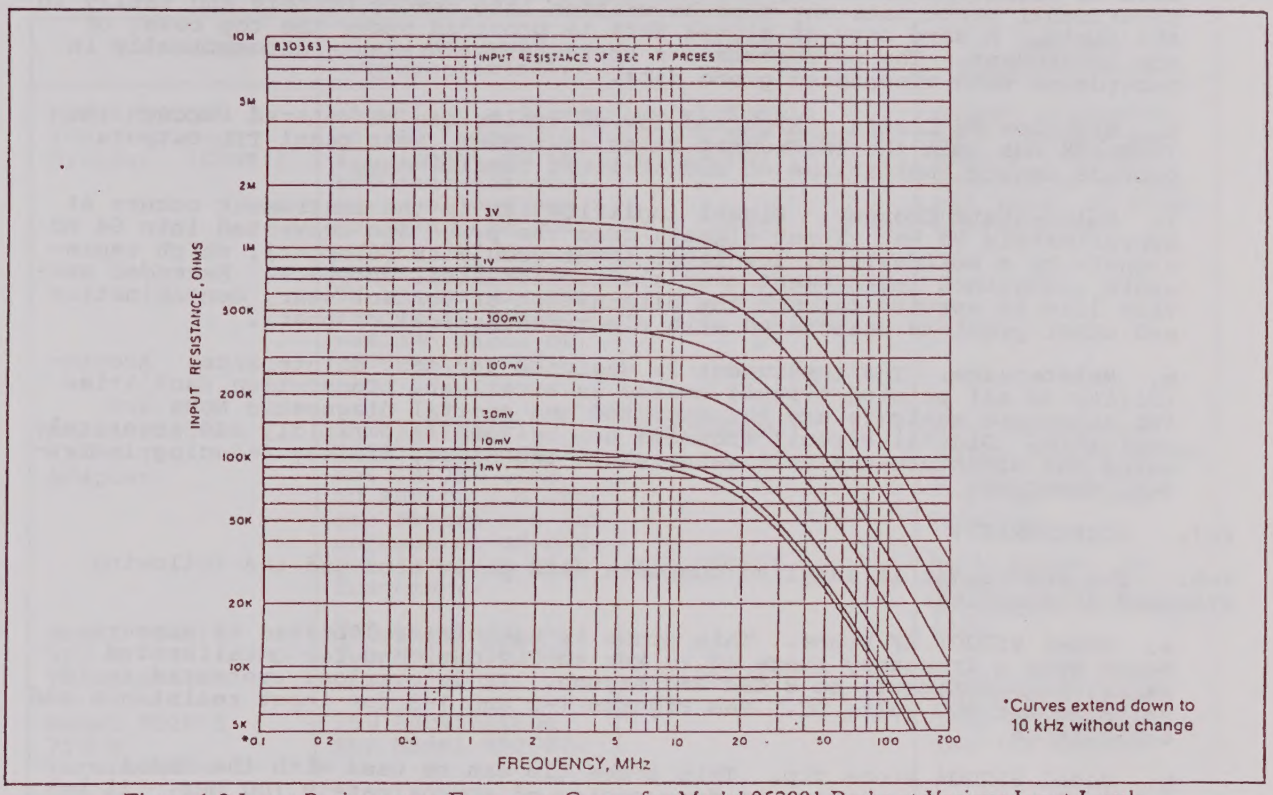


Figure 1-2 Input Resistance vs Frequency Curves for Model 952001 Probe at Various Input Levels

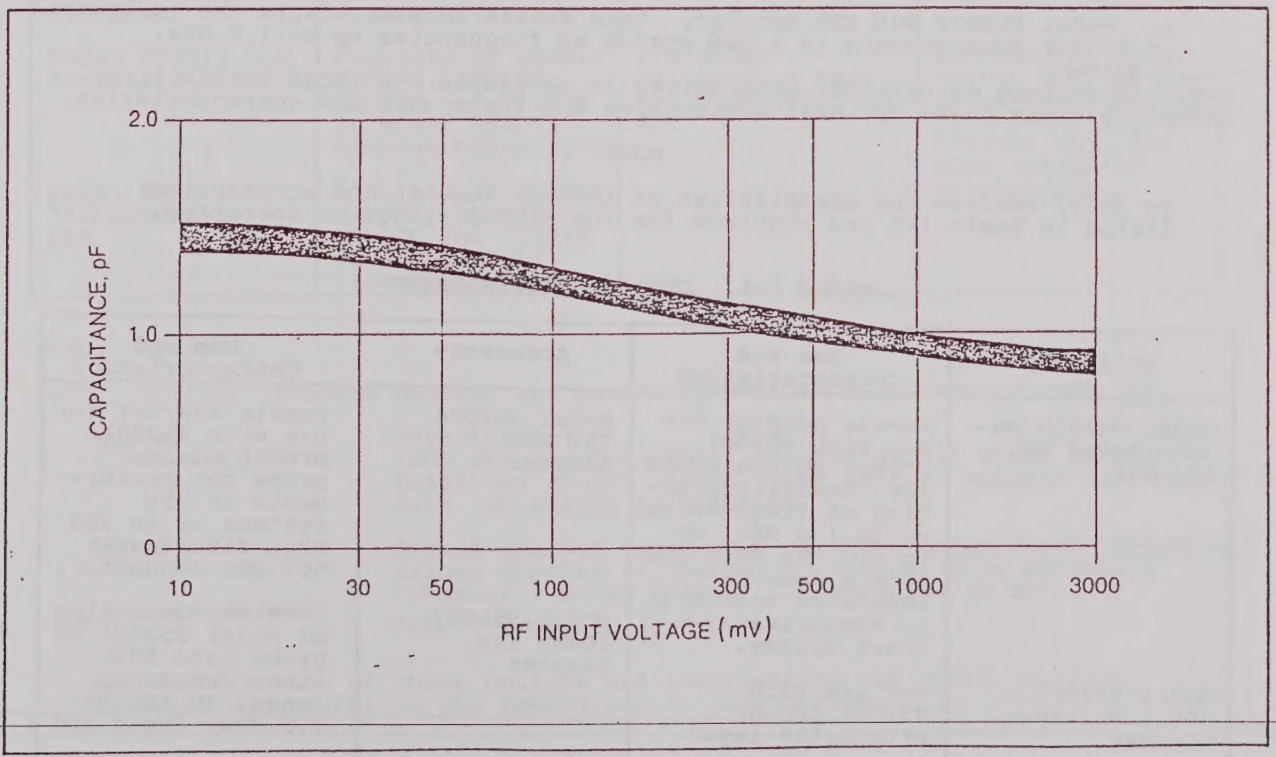


Figure 1-3 Input Capacitance vs Input Level Curve for Model 952001 Probe

1-6. (CONT.)

data is written into memory at the factory for probes ordered with the instrument; probe data may also be written into memory quickly and easily in the field. A hard copy of stored data is provided under the top cover of the instrument. The microprocessor corrects measurements automatically in accordance with the stored probe data.

k. High/Low dB Limits. High and low dB limits can be entered through the IEEE-488 Bus when the instrument is so equipped. Rear panel TTL outputs provide remote indications of out-of-limit conditions.

l. Solid-state Chopper. Signal amplification in the instrument occurs at approximately 94 Hz. Input signals from the probe are converted into 94 Hz signals by a solid-state, low-level input modulator (chopper), which represents a distinct improvement over electromechanical choppers. Extended service life is assured through the elimination of contact wear, contamination and other problems associated with electromechanical choppers.

m. Maintenance. The instrument is designed for easy maintenance. Accessibility to all printed circuit boards is excellent. Connection facilities for signature analysis are incorporated and special diagnostic ROMs are available. Digital circuit troubles can be localized rapidly and accurately using the signature-analysis maintenance technique, thereby reducing instrument downtime.

1-7. ACCESSORIES.

1-8. The instrument is supplied complete with power cord and the following standard accessories:

a. Model 952001 RF Probe. This probe is used for calibrated RF measurements over a frequency range of 10 kHz to 1.2 GHz, and for uncalibrated relative measurements to 8 GHz and beyond. It is overload protected to 10 volts AC and 400 volts DC. See Figures 1-2 and 1-3 for input resistance and capacitance.

b. Model 952004 Probe Tip. This probe tip can be used with the Model 952001 for RF measurements to frequencies of approximately 100 MHz. It has an integral grounding clip lead.

c. Model 952002 50Ω BNC Adapter. This female adapter adapts the instrument probe for measurements in a 50Ω system at frequencies up to 1.2 GHz.

ADD → D. 952665

1-9. A variety of optional accessories is available for added versatility. Table 1-1 lists these optional accessories and their uses and characteristics.

NOTE

To fully realize the capabilities of the instrument, the accessories listed in Table 1-2 are required for the listed ranges of operation.

TABLE 1-1. OPTIONAL ACCESSORIES

Accessory	Use and Characteristics	Accessory	Use and Characteristics
Model 952008 Unterminated BNC Adapter	Female adapter for use with 952001 probe; adapts probe for coaxial connection at frequencies up to 100 MHz, or to 400 MHz when fed from a low-impedance source in an electrically-short system.	Model 952006 75Ω BNC Adapter	Female adapter for use with 952001 probe; adapts probe for measurements in 75Ω systems up to 500 MHz; fitted with 50Ω BNC connector.
Model 952005 100:1 Voltage Divider	For use with 952001 probe; attenuates input	Model 952003 50Ω N Tee Adapter	Permits connection of Model 952001 RF Probe into 50Ω line; frequency range, 10 kHz to 1.2 GHz; input and

TABLE 1-1. OPTIONAL ACCESSORIES (CONT.)

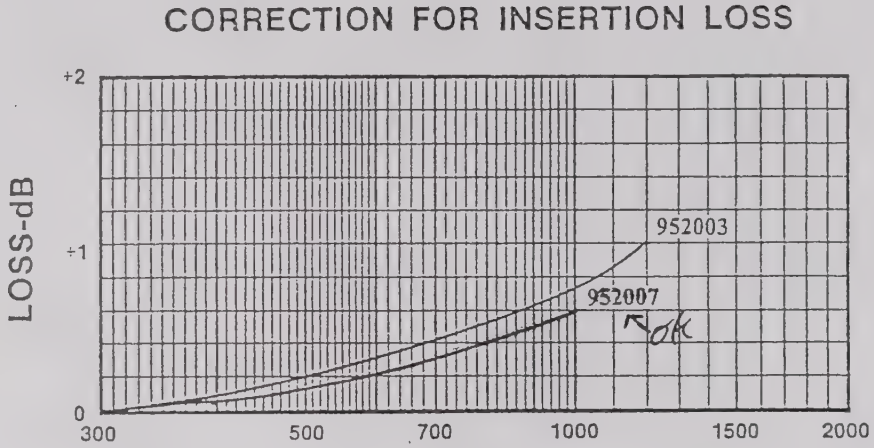
Accessory	Use and Characteristics	Accessory	Use and Characteristics
Model 952005 100:1 Voltage Divider (CONT.)	signal by a factor of 100 (adds ±(1 + $f_{MHz}/200$)% to instrument inaccuracy); allows measurements to 300 volts, RMS measurements to 3 volts; 50 kHz to 700 MHz frequency range; maximum input of 1000 volts, DC plus AC.	Model 952003 50Ω N Tee Adapter (CONT.)	output connectors both female; see Figure 1-4 for correction of output level at high frequencies.
Model 952007 75Ω N Tee Adapter	Same as Model 952003, except for use in 75Ω line 10 kHz to 1.0 GHz; see Figure 1-4 for correction of output level at high frequency.	P/N 950000	Rack mounts one Model 9200B, place either right or left on 19 inch spacing.
		P/N 950001	Rack mounts two Model 9200B instruments side-by-side.
Model 952014 50Ω N Termination	50Ω termination for Model 952003.	P/N 950002	Mounts one Model 9200B with older half-rack units, left or right.
Model 952015 75Ω N Termination	75Ω termination for Model 952007.		
Model 952013 Storage Container	Storage case for RF millivoltmeter accessories.	P/N 950029	Transit case.
Model 952011 50Ω Accessory Kit	Consists of Models 952003, 952005, 952008 and 952014 in Model 952013 Storage Container.	P/N 962001 Calibration Tape and Diagnostic ROM Kit	Contains diagnostic ROM for signature analysis checks and calibration tape for semi-automatic calibration.
Model 952012 75Ω Accessory Kit	Consists of Models 952005, 952007, 952008 and 952015 in Model 952013 Storage Container.		

1-10. OPTIONS.

1-11. Several standard options are currently available. These options are:

Number	Description
9200B-01A B	IEEE 488 Bus Interface; Duplicates all front panel functions except on/off power switch; outputs all range data and status information.
9200B-03	Second Channel Input; Two separate measurement channels; allows display of channel 1, channel 2 or channel 3 (channel 1 minus channel 2, expressed in dB).
ADD → 9200B-~~0X~~-06	ADDS MATE TO 01B INTERFACE CBL NOTE

For descriptions of these options and instructions for field installation and use, refer to the appendices to this manual.



NOTE

Attenuation shown is between the input and output ports of the tee. The instrument measures the input voltage of the tee.

Subtract the correction from the value indicated on the instrument if the output voltage of the tee is to be measured.

Do not use the correction if terminated measurements are required (Model 91-15A termination installed on the output port).

Figure 1-4 Correction Curves for Models 952003 and 952007 Type N Tee Adapters

TABLE 1-2. ACCESSORY REQUIREMENTS

Measurement Range	Required Accessories
10 kHz to 1.2 GHz	Model 952002 50Ω BNC Adapter for shielded connection to 50Ω line; Model 952006 for 75Ω line (to 500 MHz). Model 952003 50Ω Tee Adapter for connection into 50Ω line; Model 952007 for 75Ω line (to 1.0 GHz).
Above 1.2 GHz	Model 952009 50Ω terminated sensor (100 kHz-2.5 GHz).
Input levels to 300 volts, or RMS response to 3 V	Model 952005 100:1 Voltage Divider (50 kHz to 700 MHz); use with Model 952001 RF Probe only.

1-12. Option 9200B-03 is especially useful. With this option, the instrument can be fitted with two probes and can be programmed through front panel keys to display the input to either probe or the difference between the two input levels, in dB. This option simplifies the measurement of insertion loss or gain; the gain or loss is displayed directly with no need to monitor and control leveling of the signal source, other than to control the source impedance and prevent input overload.

1-13. Inquiries regarding special applications of the instrument to specific customer requirements are invited. Direct such inquiries to the Applications Engineering Department of Boonton Electronics Corporation.

1-14. SPECIFICATIONS.

1-15. Pertinent performance specifications of the instrument are listed in Table 1-3.

1-16. OUTLINE DIMENSIONS.

1-17. Outline dimensions of the instrument are shown in Figure 1-5.

TABLE 1-3. PERFORMANCE SPECIFICATIONS

Parameter	Specifications
VOLTAGE RANGE	200 µV to 3V in 8 ranges (300 V to 700 MHz with Divider). Indications down to 50 µV.
VOLTAGE DISPLAY	1.000, 3.000, 10.00, 30.00, 100.0, 300.0, 1000 and 3000 mV fs.
dB RANGE	80 dB in 8 ranges, 0.01 dB resolution.
dB DISPLAY: Units	dBmV (0 dB equivalent to 1 mV), dBV (0 dB equivalent to 1 V), dBm (0 dB equivalent to voltage drop generated when 1 mW is dissipated in selectable Z_o reference), dBr (0 dB equivalent to any desired dB reference level) or dBw (dB relative to 1W across any impedance between 20Ω and 2000Ω).
Z_o Impedance	Any value from 20 to 2000Ω.
Reference dB Offset	Any offset can be keyboard selected to 0.01 dB resolution provided that the available display range of ±99.99 dB is not exceeded.
RANGING	Autoranging plus Hold-on-range. Individual ranges may be commanded via bus interface option.
FREQUENCY RANGE	10 kHz to 1.2 GHz, Model 952001 Probe; 100 kHz to 2.5 GHz, optional Model 952009 Sensor.

TABLE 1-3. PERFORMANCE SPECIFICATIONS (CONT.)

Parameter	Specifications
WAVEFORM RESPONSE	RMS to 30 mV, calibrated in rms of a sinewave above 30 mV (RMS to 3 V and 700 MHz with Divider).
CREST FACTOR (C.F.)	Direct Input: 300 µV C.F. 140; 1 mV C.F. 42; 3 mV C.F. 14; 10 mV C.F. 4.2; 30 mV C.F. 1.4. With Divider: 30 mV C.F. 140; 100 mV C.F. 42; 300 mV C.F. 14; 1 V C.F. 4.2; 3 V C.F. 1.4.
INPUT:	
Probe, Model 952001	Button center-conductor, 1/2"-20 threaded ground shell.
Probe Tip	Needle tip, ground clip lead, Model 952004, supplied.
Adapter	50 Ω terminated BNC female, Model 952002, supplied.
Sensor, Optional	100:1 DIVIDER MODEL 952005, SUPPLIED IN PROBE CASE
Model 952009	Type N male.
Optional Accessories	Refer to Table 1-1.
Impedance	See Figures 1-2 and 1-3.
Loss	See Figure 1-4.
Maximum AC Input	10 V, all frequencies and ranges.
Maximum DC Input	400 V, all ranges.
DISPLAY	4 digit LED display of voltage or dB. Auxiliary analog display, uncalibrated, proportional to voltage (voltage mode) or dB (dB modes).
RECORDER OUTPUT	10 V fs proportional to indicated voltage (voltage mode) over each range; 8 V equivalent to 0 dBm regardless of Z_o (dB modes) with a sensitivity of 1 V per 10 dB change over the entire range.
ACCURACY:	The maximum uncertainty is the sum of the uncertainties listed in sections A, B and C.
A. Basic Uncertainty	Voltage Level: 3 mV - 3000 mV — mV: 1% rdg ±1 count; 1 mV - 3 mV — 2% rdg ±2 counts; 0.2 mV - 1 mV — 3% rdg ±3 counts; dBV, dBmV, dBm: see curve. Uncertainty vs. Input Level for dBV, dBmV, dBm, dBw
B. Frequency Effect	50 Ω MEASUREMENTS, using Model 952001 Probe with Model 952002 BNC Adapter or terminated Model 952003 N Tee Adapter. Frequency: 1 MHz (cal. frequency) — mV: 0; dBV, dBmV, dBm: 0. 10 kHz - 100 MHz — mV: 1% rdg; dBV, dBmV, dBm: 0.09 dB. 100 MHz - 1 GHz — mV: 3% rdg; dBV, dBmV, dBm: 0.27 dB. 1 GHz - 1.2 GHz — mV: 7% rdg; dBV, dBmV, dBm: 0.63 dB. SWR: 1.05 to 300 MHz, 1.10 to 1 GHz, 1.15 to 1.2 GHz

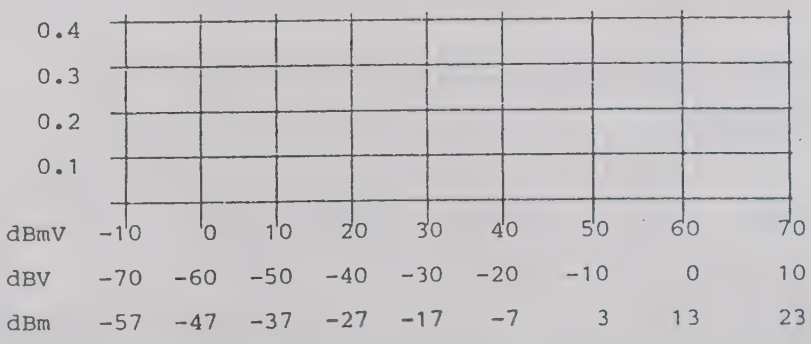


TABLE 1-3. PERFORMANCE SPECIFICATIONS (CONT.)

Parameter	Specifications
B. Frequency Effect (CONT.)	50 Ω MEASUREMENTS, using Model 952009 Terminated Voltage Sensor.

Frequency	mV	dBV, dBmV, dBm
1 MHz (cal. frequency)	0	0
100 kHz - 1 GHz	1% rdg	0.09 dB
1 GHz - 2 GHz	3% rdg	0.27 dB
2 GHz - 2.5 GHz	5% rdg	0.45 dB

SWR: 1.05 to 2 GHz, 1.10 to 2.5 GHz

75 Ω MEASUREMENTS, using Model 952001 Probe with Model 952006 BNC Adapter.

Frequency	mV	dBV, dBmV, dBm
1 MHz (cal. frequency)	0	0
10 kHz - 100 MHz	1% rdg	0.09 dB
100 MHz - 300 MHz	3% rdg	0.27 dB
300 MHz - 500 MHz	6% rdg	0.54 dB

SWR: 1.05 to 150 MHz, 1.10 to 300 MHz, 1.20 to 500 MHz

75 Ω MEASUREMENTS, using Model 952001 Probe with terminated Model 952007 N Tee Adapter.

Frequency	mV	dBV, dBmV, dBm
1 MHz (cal. frequency)	0	0
10 kHz - 100 MHz	1% rdg	0.09 dB
100 MHz - 700 MHz	3% rdg	0.27 dB
700 MHz - 1 GHz	7% rdg	0.63 dB

SWR: 1.05 to 150 MHz, 1.10 to 750 MHz, 1.25 to 1 GHz

Add 952016 + 952016 with 952058

C. Temperature Effect

Model 952001 Probe or Model 952009 Sensor. Add 952016

Temperature	mV Instrument	mV Probe/ Sensor	dBV, dBmV, dBm Instrument	dBV, dBmV, dBm Probe/ Sensor
21°C - 25°C	0	0	0	0
18°C - 30°C	0	1% rdg	0	0.09 dB
10°C - 40°C	1% rdg	5% rdg	0.09 dB	0.45 dB
0°C - 55°C	2% rdg	12.5% rdg	0.18 dB	1.16 dB

LINE STABILITY	Less than 0.2% rdg with ±10% line voltage change at reference line conditions of 115 to 120 V, 50 to 400 Hz. Usable after 5 min. warmup.
ZERO	Automatic, operated by panel key switch.
dB LIMITS	IEEE-488 Bus selectable dB limits, range ±99 dB, resolution 0.01 dB. Rear panel TTL outputs indicate high or low condition.
ANNUNCIATORS	LEDs indicate V, mV, dBV, dBmV, dBm, dBw, dBr and X100. Also show use of channel 1 (CH1), channel 2 (CH2) or channel 3 (CH3) with option -03 where CH3=CH1-CH2 in dB. Indicate IEEE-488 bus activity (LSN, ATN, REM and TLK) with option -01B.
POWER	100, 120, 220, 240 V ±10%, 50-400 Hz; 24 VA.
WEIGHT	10 lbs. (4.54 kg) approx.
DIMENSIONS	See Figure 1-5.
OPTIONS 01AB IEEE 488 Bus Interface	Duplicates all front panel functions plus range hold and dB limits except on/off power switch. In addition, individual voltage and dB ranges may be selected and selectively zeroed. This interface implements the following subset of the IEEE 488 1978 Standard:
	SH1 Source handshake, complete capability.

TABLE 1-3. PERFORMANCE SPECIFICATIONS (CONT.)

Parameter	Specifications
OPTIONS 01AØIEEE 488 Bus Interface (CONT.)	AH1 Acceptor handshake, complete capability. T6 Basic talker, serial poll, unaddress if MLA, no talker only capability. TE0 No extended talker capability. L4 Basic listener, run address if MTA, no listener only capability. LE0 No extended listener capability. SR1 Service request capability. RL1 Remote-local capability, local lockout. PP0 No parallel poll capability. DC1Ø No Device clear capability. DT1 Device trigger capability. C0 No controller capability. Output data and status information follows the following format: abcsddddEsd,S,R(cr)*(lf)* ab=mode (MV=voltage in mV; DM=dBmV; DR=dB reference; DV=dBV; DB=dB. c=channel (A=1; B=2; C=3). s=sign (+ or -). dddd=data (four digits, each digit 0 thru 9). Esd=exponent, sign, digit. S=status digit. 0 no error 1 entry too small 2 entry too large 3 underrange 4 overrange 5 zero acquisition out of range — excessive negative offset (hardware malfunction) 6 zero acquisition out of range — excessive positive offset (input too large) 7 channel 3 over/underrange R = range digit 0 1 mV 1 3 mV 2 10 mV 3 30 mV 4 100 mV 5 300 mV 6 1000 mV 7 3000 mV *cr = carriage return (user selected terminator). *lf = line feed (user selected terminator).
03 Input Channel 2	Allows display of either Channel 1 or Channel 2, or Channel 3 which is CH1 minus CH2 expressed in dB. Includes second Model 952001 RF Probe, with Model 952004 Probe Tip and Model 952002 50 Ω BNC Adapter.

ADD

06 MATE ENABLES VOLTMETER TO RUN UNDER CIIL CONTROL REQUIRES 01B INTERFACE.

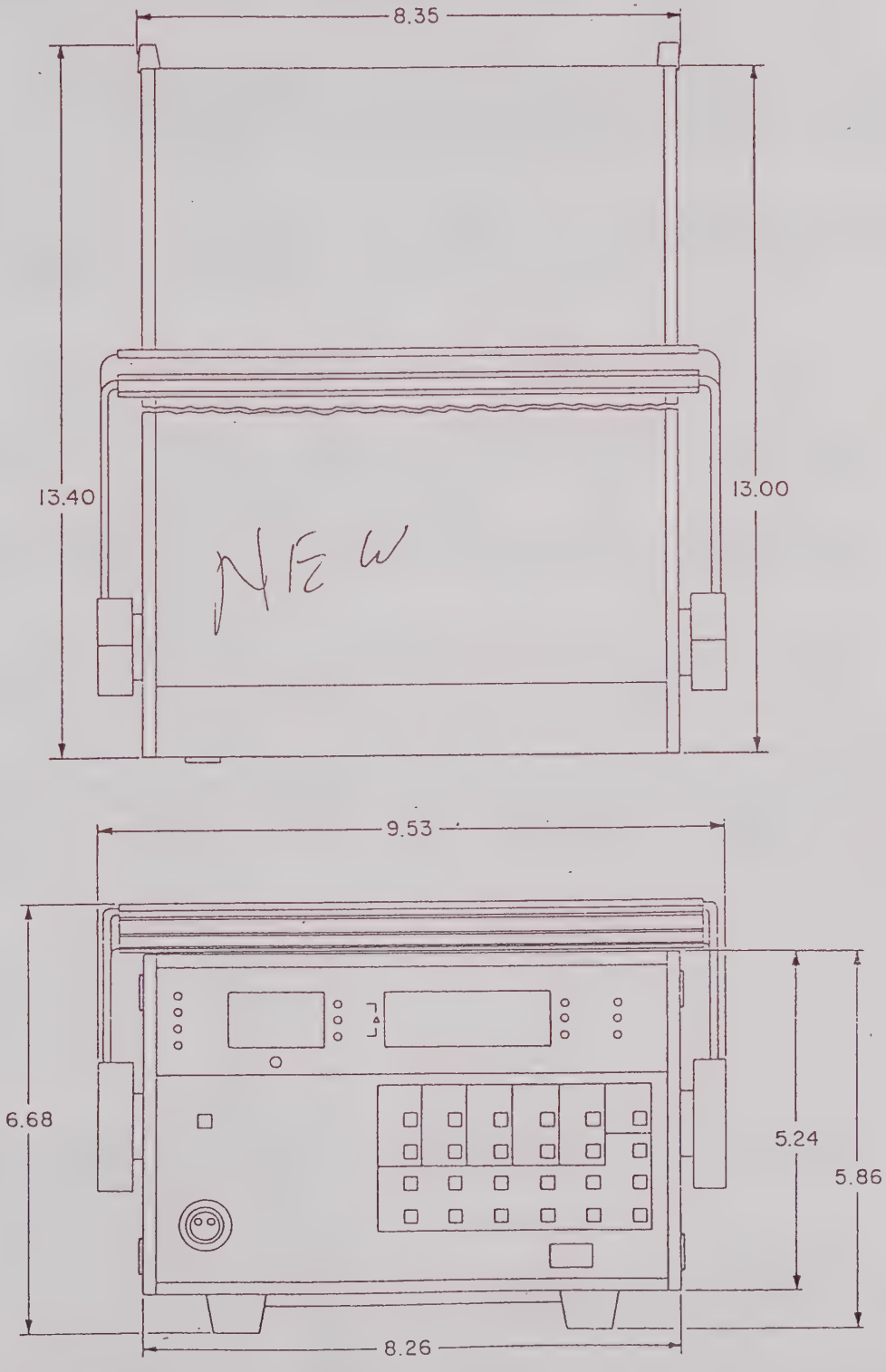


Figure 1-5. Outline Dimensions

SECTION II

OPERATION

2-1. GENERAL.

2-2. This section provides instructions for installation and operation of the instrument. It is recommended that the operator familiarize himself thoroughly with the material in this section before attempting to operate the instrument; otherwise, the full capabilities of the instrument may not be realized in use.

2-3. INSTALLATION.

2-4. Unpacking. The instrument is shipped complete with probe, and is ready for use upon receipt. Unpack the instrument carefully and inspect it for any signs of shipping damage. Should any damage be noted, notify the carrier and the factory immediately.

NOTE

Save the packing material and container for possible use in reshipment of the instrument.

2-5. Mounting. For bench use, choose a clean, sturdy, uncluttered surface. For rack mounting, an accessory package, part number 950000, is available for mounting one instrument; a second accessory package, part number 950001, is available for mounting two instruments side-by-side.

2-6. Power Requirements. The instrument has a tapped power transformer which permits operation from 100, 120, 220 or 240 volt ±10%, 50 to 400 Hz, single phase AC power sources. Power consumption is approximately 24 voltamperes at 60 Hz.

2-7. Cable Connections. Interconnecting cable connections required depend upon the options installed and the system applications of the instrument. A line cord and a voltage probe are supplied with the instrument, a second voltage probe is supplied with option 9200B-03. Any other cables required must be supplied by the user. Cable connections that may be required are as follows:

a. Recorder Output. The rear-panel RECORDER connector (type BNC) provides an analog DC voltage that is linear with voltage over each decade range in the mV measurement mode, or linear in dB over the entire 80 dB range in any of the dB modes. Output impedance is approximately 9000Ω. Maximum current capability is 1 milliampere into 1000 ohms. Full scale DC voltage for each range in the mV mode is 10 volts. Output voltage in all dB modes is as follows:

Measured dBV	Output Voltage
+10	10 volts
0	9 volts
-10	8 volts
-20	7 volts
-30	6 volts
-40	5 volts
-50	4 volts
-60	3 volts
-70	2 volts

b. Status Output. Rear panel connector P3 provides signal outputs for input disconnect during zeroing operations and high and low dB limit signals. Pin connections are as follows:

Connector Pin	Signal
1	Common
2	Not used
3	Logic high indicates zeroing operation
4	Logic low if measured value is within dB limits; logic high if measured value is above high dB limit
5	Logic low if measured value is within dB limits; logic high if measured value is below low dB limit

2-8. OPERATING CONTROLS, INDICATORS AND CONNECTORS.

2-9. Controls, indicators and connectors used during operation of the instrument are shown in Figures 2-1 and 2-2. Table 2-1 lists their functions.

2-10. POWER APPLICATION.

2-11. The instrument is designed for operation from a 100, 120, 220 or 240 volt, 50 to 400 Hz, single phase AC power source. To apply AC power, proceed as follows:

a. Determine the line voltage at the AC power output receptacle.

b. Set the two slide switches on the rear panel to conform to the available AC line voltage.

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS

Control, Indicator or Connector	Figure and Index No.	Function
LSN, ATN, REM and TLK annunciators	2-1,1	Provide indication of activity when IEEE 488 bus interface option 9200B-01B is in use.
Meter	2-1,2	Provides relative indication of voltage or dB for peaking and nulling operations.
CH1, CH3 and CH2 annunciators	2-1,3	Indicate which channel has been selected for use.
MODE keys	2-1,4	Provide means for selecting display indication mode (mV, dBm, dBmV, dBV, dBw or X100).
LED display	2-1,6	Four digit LED display with minus sign and decimal point; provides numeric indication of measured voltage or dB level, or data entered or recalled through keyboard, or error messages.
mV, dBV and dBmV annunciators	2-1,7	Indicate measurement units.
dBm, dBw and dBr annunciators	2-1,8	Indicate whether displayed measurement values in dB modes are absolute (dBm) or relative (dBr) values.
SELECT keys	2-1,11	Provide means for entering or recalling probe number or serial number or for entering or recalling channel number (CHNL).
REF LEVEL dB key	2-1,12	Provides means for entering or recalling a dB reference level.
Numerical, decimal point and CHS keys	2-1,13	Provide means for entering signed numeric data.
LINE switch	2-1,14	Controls application of AC line power to instrument.
PROBE connectors	2-1,15	Provides means for connecting probes to input channels of instrument.
ZERO key	2-1, 16	Provides means for automatic acquisition and storage of zero corrections for each range.
J1 connector	2-2, 1	Option: provides IEEE 488 bus connections when option 9200B-01B is installed.

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (CONT.)

Control, Indicator or Connector	Figure and Index No.	Function
S1 switch	2-2, 2	Option: used to set address of instrument and termination characters when IEEE 488 bus option 9200B-01B is installed.
P3 connector	2-2, 3	Provides logic signal outputs for input disconnect during zeroing, high dB limit and low dB limit.
Power connector	2-2, 4	Provides means for connecting instrument to AC power source; contains power fuse and voltage change card for 100, 120, 220 or 240 volt AC operation.
RECORDER connector	2-2, 5	Provides analog DC output, which is proportional to measured voltage or dB level, for application to recorder.
REAR CHNL 2 connectors	2-2, 6	Provides means for rear connection to input channels.

c. Check the rating of the fuse in the rear panel fuseholder. For operation from a 100 or 120 volt AC power source, the fuse should be a 0.3 ampere, MDL Slo-Blo type; for 220 or 240 volt operation, it should be a 0.2 amperes, MDL Slo-Blo type. If the rating of the fuse is incorrect, install a fuse of the correct rating in the fuseholder.

WARNING

This instrument is designed to operate from a 3-terminal (one ground) AC power receptacle. If only a 2 terminal AC power receptacle is available, use a 3 prong to 2 prong adapter. Connect the adapter ground wire to the power receptacle ground to eliminate a potential shock hazard to the operator.

d. Connect the power cord between the AC power connector on the rear panel of the instrument and the AC power receptacle (using an adapter if necessary).

2-12. PRELIMINARY CHECK OF INSTRUMENT.

NOTE

The following checkout procedure is intended merely to demonstrate that the major circuits of the instrument are operating before the instrument is placed in service. For a detailed check of the instrument against performance specifications, refer to paragraph 2-28.

2-13. To perform a preliminary operational check, proceed as follows:

a. Set the LINE switch to the ON position.

b. Check operation of the LED display and the numerical keys by pressing the following keys in the sequence indicated and noting the LED display:

Press	Display	Press	Display	Press	Display
CLR	0000	3	0123	7	4567
•	0000.	CLR	0000	CLR	0000
0	000.0	4	0004	8	0008
1	00.01	5	0045	9	0089
2	0.012	6	0456	CHS	-0089

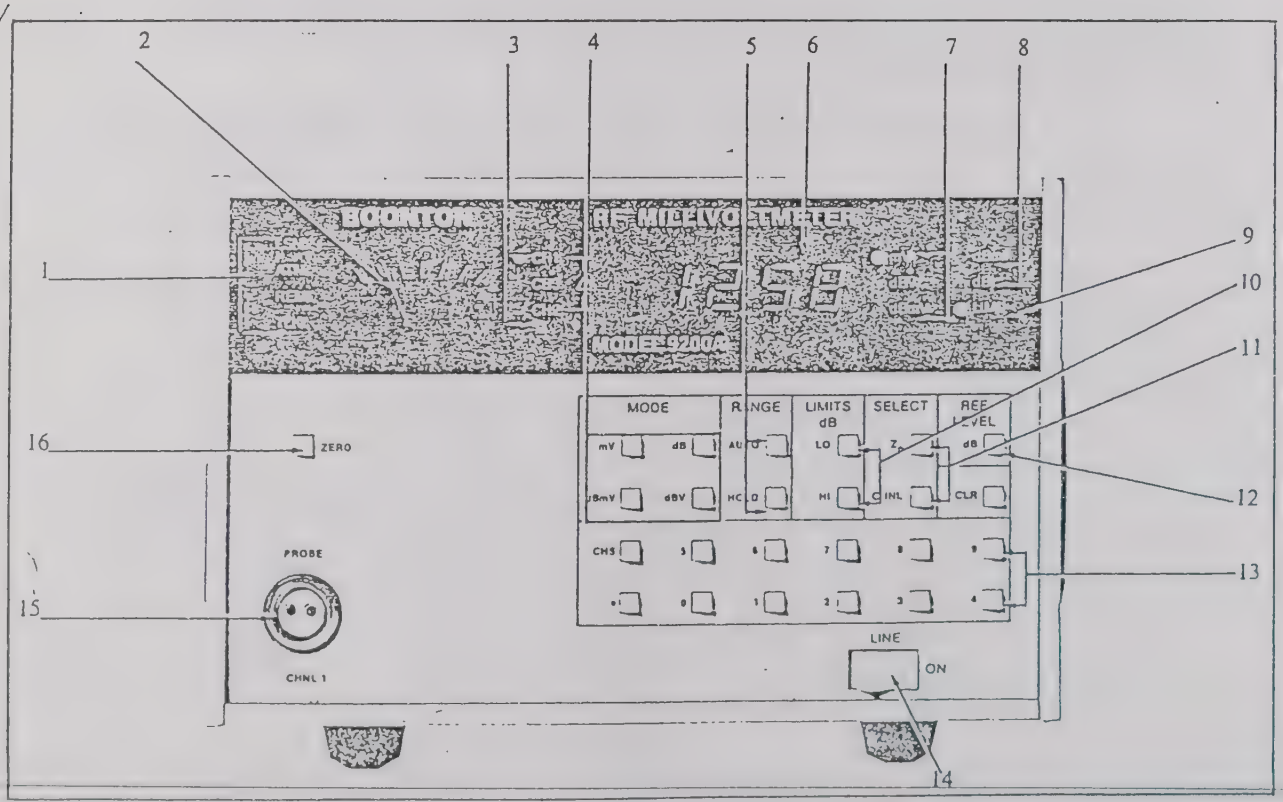


Figure 2-1 Front View of Instrument

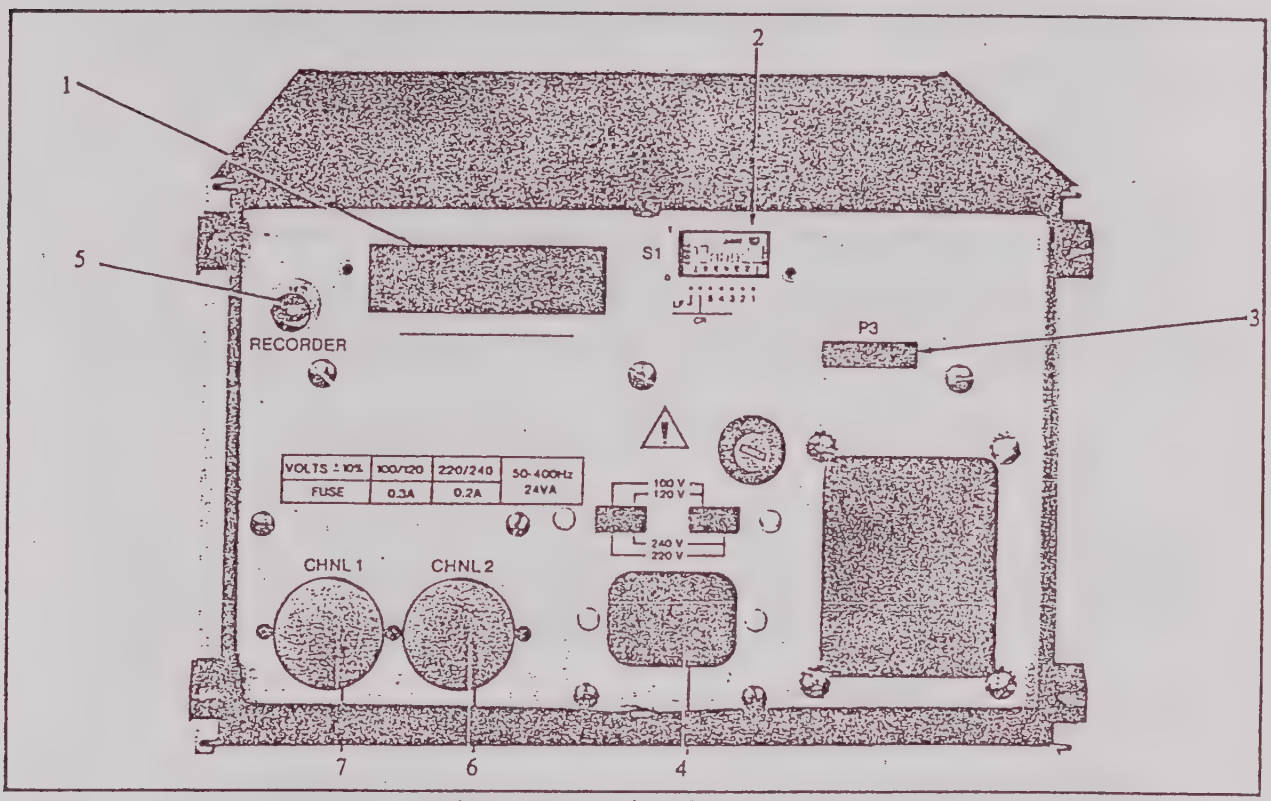


Figure 2-2 Rear View of Instrument

NEW

2-13. (CONT.) SUPPLIED WITH

c. Connect the probe that is marked Channel 1 to the front-panel PROBE connector.

d. Enter measurements parameters by pressing the following keys:

1 SELECT CHNL
0 REF LEVEL dB
MODE dBm
50 SELECT Z_o

e. Check to see that the dBm and CH1 annunciators are lighted.

f. With zero input to the probe, press the ZERO key. The instrument will go through an automatic zeroing cycle. During the zeroing cycle the display will blank; in approximately 18 seconds, the display will return and show cc 3, indicating that zeroing is complete and the input level is underrange.

SHOW CCCC

NOTE

The 9200B will display eight error codes, as follows:

cc 1	entry too small
cc 2	entry too large
cc 3	measurement underrange
cc 4	measurement overrange
cc 5	zero acquisition out of range - excessive negative offset (hardware malfunction, e.g., input connector polarity reversed, or negative chopper offset)
cc 6	zero acquisition out of range - excessive positive offset (input too large)
cc 7	channel 3 over/underrange
cc 8	probe (sensor) serial number is not in instrument's memory

g. Connect the Model 952001 probe to a low impedance 1 MHz source, such as the Boonton Model 26A RF Millivoltmeter Calibrator, using the Model 91-6G unterminated BNC adapter supplied with the Model 26A.

NOTE

The Model 26A RF Millivoltmeter Calibrator is designed to operate into a high impedance load, such as the Model 952001 RF Probe. If the instrument is fitted with the Model 952009 RF Sensor, which has a built-in 50Ω termination, it will be necessary to modify the output circuit of the Model 26A, as follows:

1. Disconnect AC power to the Model 26A.

2. Remove the bottom cover by removing the securing screw at the rear and then sliding the cover to the rear.

3. Remove the TNC 50Ω termination from the tee adapter at the output of the calibrator.

4. Replace the bottom cover, and apply AC power.

5. Connect the Model 952009 Sensor to the calibrator using a Type N to BNC adapter.

h. Set the output of the calibrator to 1000 millivolts and press the following instrument keys:

1 SELECT CHNL
1 PROBE (SENS)
MODE mV
0 REF LEVEL dB
50 SELECT Z_o

The CH1 annunciator should be lighted and the instrument display should indicate approximately 1000 mV.

2-13. (CONT.)

i. Press the MODE dBmV key. The indication on the instrument display should be approximately 60.00 dBmV.

j. Press the MODE dBm key. The indication on the instrument display should be approximately 13.01 dBm.

k. Press the numerical 1 key, then press the REF LEVEL dB key. The indication on the instrument display should be approximately 12.01 dBr.

l. Press the 1 and CHS numerical keys, then press the REF LEVEL dB key. The indication on the instrument display should be approximately 14.01 dBr.

m. Press the CLR key, then press the REF LEVEL dB key. The indication on the instrument display should be approximately 13.01 dBm.

n. Press the MODE dBV key. The indication on the instrument display should be approximately 00.00 dBV.

o. Set the output level of the calibrator to 300 millivolts. The instrument display should indicate approximately -10.46 dBV.

p. Set the output level of the calibrator to 3 volts. The indication of the instrument display should be approximately 9.54 dBV.

q. If the instrument is supplied with the second channel option (option 9200B-03), repeat steps g through o for channel 2, pressing the 2 SELECT CHNL key in step g in the place of the 1 SELECT CHNL key, connecting probe 2 to the channel 2 input connector and connecting the channel 2 probe to the calibrator. A BNC tee can be used to connect both probes to the calibrator at the same time.

r. To check channel 3 operation with option 9200B-03 installed, proceed as follows:

1. Connect the channel 1 and channel 2 probes to the Model 26A RF Millivoltmeter Calibrator, using a BNC tee adapter and two model 91-6G unterminated BNC adapters supplied with the Model 26A.

2. Enter channel 1 and channel 2 measurement parameters by pressing the following keys in the given sequence:

1 SELECT CHNL
1, PROBE (SENS)
0 REF LEVEL dB
MODE dBm
50 SELECT Z_O
2 SELECT CHNL
2, PROBE (SENS)
0 REF LEVEL dB
MODE dBm
50 SELECT Z_O

3. Set the output level of the calibrator to 1000 millivolts and press the 3 SELECT CHNL key. The indication on the instrument display should be approximately 00.00 dBr, which is the difference in dB with channel 2 as the reference.

NOTE

The dB mode last chosen for each channel prior to channel 3 selection is operative after channel 3 selection.

s. Turn off the calibrator and disconnect the probe(s) from the calibrator.

2-14. OPERATING PROCEDURES.

2-15. Programming Measurement Parameters.

a. General. Measurement parameters for each channel of the instrument are entered into the microprocessor through the front-panel keyboard. To eliminate the need for repeated reprogramming, parameters entered through the keyboard are stored in non-volatile memory, and the stored parameters are

unaffected by instrument turn-off and turn-on. It is important to remember that the last used parameters are stored in the instrument because these stored parameters could cause what appear to be erroneous indications when subsequent measurements that require different parameters are made. Measurement parameters may be changed at any time. The following keys may be used to recall the last entered value for the corresponding functions:

AVERAGE SEC, SELECT PROBE
SELECT Z_o, SELECT CHNL and
REF LEVEL dB

NOTE

Entered measurement parameters apply only to the channel in use at the time that the parameter entries were made. If the instrument is equipped with the second channel option (option 9200B-03), different measurement parameters may be entered for channel 1 and channel 2. When either channel is selected thereafter, measurement parameters that had been entered for that channel are invoked automatically by the microprocessor.

When the instrument is in store or recall mode, the LED display and annunciators blink on and off to alert the operator to the fact that the displayed value is not a measured value, but a value that has been recalled from instrument memory or that is to be entered into memory.

b. **Probe Selection.** The Model 9200B is supplied with either the Model 952001 high impedance probe or the Model 952009 50Ω sensor as ordered for channel 1 (and channel 2, option 9200B-03 if ordered).

c. **Use of Numerical Keys.** The numerical keys are used to enter values for SELECT, PROBE SELECT, AVERAGING CONSTANT, Z_o and REF LEVEL dB functions. When any numerical key is pressed, the microprocessor interrupts the measurement operation to accept new data. Numerical values are entered in normal sequence and keyed-in values enter the instrument display from right to left. Up to four digits, plus decimal point and minus sign, can be entered; entries exceeding four digits are ignored. Pressing the decimal-point key places a decimal point after the right-most digit in the instrument display. Pressing the CHS key changes the sign of the entry (plus becomes minus, or minus becomes plus); the plus sign is not displayed. If an error is made during entry of numerical values, press the CLR key and repeat the data entry process. When the instrument display shows the desired numerical value, pressing the applicable SELECT or dB REF LEVEL key will cause the microprocessor to store the keyed-in value and return automatically to the measurement cycle.

d. MODE Selection. The MODE keys enable the operator to select the desired measurement mode. When the MODE mV key is pressed, measurement values are displayed in millivolts. When the MODE dBmV key is pressed, measured levels are displayed in dB referred to 1 millivolt. When the MODE dBV key is pressed, measured levels are displayed in dB referred to 1 volt. When the MODE dBm key is pressed (and a 0 dB reference level has been entered), measured levels are displayed in dB referred to the voltage that produces 1 milliwatt in the selected Z_o reference impedance (the Z_o value must be entered through the keyboard). When the MODE dBw key is pressed (and a 0 dB reference level has been entered), measured levels are displayed in dB referred to the voltage that produces 1 watt in the selected Z_o. The displayed numerical values may be expressed as follows:

$$dB = 20 \log \frac{e_{measured}}{e_{reference}}$$

For dBm, $e_{reference} = (Z_o \times 10^{-3})^{1/2}$
For dBw, $e_{reference} = (Z_o)^{1/2}$

In the dB mode, entering a dB reference level other than 0 causes lighting of the dBr annunciator and displayed dB mode measurement values represent dB with respect to the selected reference level. Resolution of the instrument in any dB mode is 0.01 dB.

e. X100 Key. The X100 key is used with the 952005 100:1 Voltage Divider. By pressing the X100 key when the 952005 Divider is installed on a probe,

the display is corrected to read the true voltage or dB and is active in all voltage and dB modes. This saves the operator from making a mental correction or recalculating dB by hand. The X100 function can be used independently on both channels and the X100 annunciator will light to inform the operator that the channel selected in in the X100 mode. To return to the X1 mode, press the X100 key.

f. Probe (Sensor) Select. The Model 9200B can accommodate data storage for up to eight probes or sensors. The desired probe is selected by pressing N (N: digit 1 thru 8) and SELECT PROBE keys. The data for N Probe (if previously stored see Section 4-33) will now be used in the measurement process. The probe number for data in effect can be recalled by pressing the SELECT PROBE key. The display will show the probe number. The serial number of each probe (sensor) is also stored in the instrument's memory and can be recalled by pressing the •, SELECT PROBE keys. This is helpful in assuring that the correct probe has been installed and selected. If the probe (sensor) number is not known, the correct data can be recalled by entering the probe (sensor) serial number followed by pressing the •, SELECT PROBE keys. The correct data and probe number will now be matched to the probe in use.

If a particular probe (sensor) is desired with a particular channel this is obtained by selecting the channel first followed by the probe selection (e.g. 1 CHNL, 1 PROBE). Whenever Channel 1 is now selected Probe 1 is also selected.

g. AVERAGE Function Selection. To reduce the effects of noise, spurious components, etc. at lower levels, the Model 9200B employs signal averaging. The amount of averaging is a function of signal level, being highest on the lowest ranges and least on the highest ranges. When the instrument is first turned on a set of default values is assigned as follows:

F.S. LEVEL	RANGE	CONSTANT
3000 mV	7	1
1000 mV	6	1
300 mV	5	1
100 mV	4	1
30 mV	3	2
10 mV	2	4
3 mV	1	20
1 mV	0	80

If it is desired to increase or decrease these values on any or all ranges, this may be accomplished by pressing N (N = 1 to 128) and then the AVERAGE SELECT keys. The constant for this range will remain in effect until changed by entering a different value, or until the AVERAGE AUTO key is pressed or the instrument is turned off/on after which the default values will again be in effect. This value of the constant effective on a range can be recalled with the instrument on that range by pressing the •, AVERAGE AUTO keys.

h. PROBE (SENS) Serial Number Recall. To recall the serial number of a probe, first select the probe (N, PROBE), then press •, PROBE keys. The display will now show the serial number for the probe selected. PROBE (SENS) serial number entry is covered in Section 4-33.

i. CLEAR key. If an error is made in keying in a numeric entry pressing the CLEAR key will clear the display to all zeros and the value may be rekeyed. Additionally, the CLEAR key may be used to clear to zero the value stored for dB reference by pressing the CLEAR key followed by the dB REFERENCE key. During IEEE-488 Bus operations, the CLEAR key is used as the Return to Local key, whereby pressing it returns control of the instrument to the front panel.

j. SELECT Function Selection. The SELECT keys are used by the operator to specify the number of the measurement channel and the probe.

NOTE

Selecting a channel also selects probe data and measurement parameters that had been entered into non-volatile memory for that channel and PROBE (SENS).

1. The basic instrument contains only one measurement channel. This channel is designated channel 1 and the front panel CHANNEL connector provides the input to this channel. An option is available for the addition of a second measurement channel. When this option (option 9200B-03) is included, the additional measurement channel is designated channel 2.

2. To further enhance the usefulness of the instrument, a channel 3 operation may be exercised if the instrument is equipped with option 9200B-03. The indication in channel 3 mode is:

	Channel 1		Channel 2
Display =	dBmV or dBV or (dBm - REF LEVEL dB) or (dBw - REF LEVEL dB)	-	dBmV or dBV or (dBm - REF LEVEL dB) or (dBw - REF LEVEL dB)

The dB mode operative for each channel in channel 3 operation is the last dB mode chosen for that channel prior to selection of channel 3 operation. This is true even if the mV mode is chosen prior to channel 3 selection. Mixed modes are also possible, that is, either channel may be operating in any of its modes (mV, dBmV, dBV dB or dBw). If either or both channels are operating in the dB mode, the REF LEVEL dB function is also operative. Examples of channel 3 operation are listed in Table 2-2.

3. Channel 1 measurements, channel 2 measurements or the channel 3 function can be selected using the numerical keys and the SELECT CHNL key.

Example: To select the channel 1 input for measurement:

Press	Display
1	0001
SELECT CHNL	Reverts to measurement.

4. The SELECT Z_O key enables the operator to enter a desired reference impedance for dB mode measurements. (When the MODE dBm key is pressed, measured input levels are displayed in dBm referred to the voltage that produces 1 milliwatt of power in the selected reference impedance.) Valid Z_O values are 5 through 2500 ohms.

Example: To select a reference impedance of 50 ohms:

Press	Display
5	0005
0	0050
SELECT Z_O	Reverts to measurement.

k. REF LEVELS dB Selection. The following standard reference levels are operative in the dB modes:

Mode	Level (0 dB)	Annunciator
dBmV	1 mV	dBmV
dBV	1 V	dBV
$dB(Z_O)$	$dB(Z_O \times 10^{-3})^{1/2}$	dBm
$dBw(Z_O)$	$dB(Z_O)^{1/2}$	dBw

Entering a number other than 0 into the REF LEVEL dB results in this number becoming the reference level for the dB mode. The display will indicate reference level and the dBr annunciator will be activated. The dB reference level affects the dB mode only. The dB reference level may be entered while any mode is being used, but the result of the entry will be apparent only when returning to the dB mode.

It is possible to select the present dB level as the dB reference level by pressing the • and REFERENCE LEVEL dB keys.

1. To display dBr to a reference level of -15.3 dB, for example:

2-15. (CONT.)

Press	Display	Annunciators dBm	dBr
MODE dBm	Measurement	Lighted	Off
CLR	0000	Lighted	Off
REF LEVEL dB	dB Measurement	Lighted	Off
1	0001	Lighted	Off
5	0015	Lighted	Off
•	0015.	Lighted	Off
3	015.3	Lighted	Off
CHS	-015.3	Lighted	Off
REF LEVEL dB	dB Measurement	Lighted	Lighted

NOTE

Maximum display capability for dBr is ±99.99 dB.

2. To return to a dBm measurement:

Press	Display	Annunciators dBm	dBr
0 or CLR	0000	Lighted	Lighted
dB REF LEVEL	dB Measurement	Lighted	Off

TABLE 2-2. EXAMPLES OF CHANNEL 3 MEASUREMENTS

Channel 1					
No.	Input	Mode	Z_o	REF LEVEL dB	Display
1	1000 mV	mV	-	0	1000 mV
2		dBmV	-	0	60.00 dBmV
3		dBV	-	0	00.00 dB
4		dBm	50	0	13.01 dBm
5		dBm	50	5	8.01 dBr
6		dB	50	5	8.01 dBr
7		mV	50	5	1000 mV
8		mV	50	5	1000 mV

Channel 2						
No.	Input	Mode	Z_o	REF LEVEL dB	Display	Channel 3 Display
1	1000 mV	mV	-	0	1000 mV	(See Note)
2		dBmV	-	0	60.00 dBmV	00.00 dBr
3		dBmV	-	0	60.00 dBmV	-60.00 dBr
4		dBm	50	0	13.01 dB	00.00 dBr
5		dBm	50	0	13.01 dB	-05.00 dBr
6		dBmV	50	0	60.00 dBmV	-51.99 dBr
7		dBmV	50	0	60.00 dBmV	-51.99 dBr
8		mV	50	0	1000 mV	-51.99 dBr

NOTES:

For No. 1 measurement, the channel 3 indication is a function of previously selected dB modes, unknown at this time.

For No. 2 measurement, the channel 3 indication = 60 dBmV - 60 dBmV = 0 dBr.

For No. 3 measurement, the channel 3 indication = 0 dBV - 60 dBmV = -60 dBr.

For No. 4 measurement, the channel 3 indication = 13.01 dBm - 13.01 dBm = 0 dBr.

2-15. (CONT.)

For No. 5 measurement, the channel 3 indication = (13.01 dBm - 5 dB) dBr - 13.01 dBm = -5 dBr.

For No. 6 measurement, the channel 3 indication = (13.01 dBm - 5 dB) dBr - 60 dBmV = -51.99 dBr.

For No. 7 and No. 8 measurements, the channel 3 indication is the same as for the No. 6 measurement because if the mV mode was chosen for channel 1 and/or channel 2 prior to channel 3 selection, that channel will revert to the dB mode used prior to selection of the mV mode.

2-16. Zeroing the Instrument. For greatest accuracy, especially on the more sensitive ranges, the instrument must be zeroed. To eliminate the need for tedious and often inaccurate manual zeroing, the instrument incorporates an automatic zeroing capability. When automatic zeroing is initiated, the microprocessor reads, averages and stores zero corrections for each measurement range of the instrument and applies the proper zero correction for the range in use for all subsequent measurements. Zero corrections are most important on the more sensitive ranges of the instrument. During instrument warmup periods and during use in environments with varying ambient temperatures, the instrument should be zeroed frequently if measurements are being made on the lower ranges. To zero the instrument, proceed as follows:

CAUTION

Never press the ZERO key with a signal applied to the probe. To do so will result in erroneous zero corrections and inaccurate subsequent measurements. If the input exceeds normal zero offsets, error flag cc6 will be displayed when automatic zeroing is initiated; remove the input signal and re-zero the instrument.

a. Remove all input signal to the probe. This can be done by unscrewing the probe tip until the tip just breaks contact with the internal connection, leaving the metal shell engaged with the probe body threads. Alternatively, the probe tip can be removed and a Model 952002 50Ω adapter connected in its place.

b. Press the ZERO key. The automatic zeroing cycle takes approximately 18 seconds; the microprocessor computes and stores zero corrections during this this period. When the ZERO key is pressed, a logic signal is activated at rear panel connector J3; this signal can be used to initiate turn-off of the device to which the instrument probe is connected if such operation is desired. When zeroing is complete, the instrument display shows cc03 in all dB modes, indicating input underrange. In the mV mode, the underrange indication does not appear; the instrument display shows the "zero condition". This is composed of residual noise and offsets and, ideally, should show + and - excursions of similar amplitude less than 100 counts.

2-17. Making Measurements. Once the instrument has been programmed and zeroed, it is ready for voltage or dB level measurements. Merely connect the probe to the source whose voltage or dB level is to be measured; the measured level will be displayed directly.

2-18. APPLICATION NOTES.

2-19. Overload Limits.

a. The Model 952001 RF Probe supplied with the instrument is overload-protected to 10 volts AC and 400 volts DC. Exceeding these limits may result in permanent damage.

b. The Model 952002 50Ω BNC Adapter supplied with the instrument should not be subjected to continuous overload of more than 10 volts (DC + RMS AC) in order to avoid excessive heating of the terminating resistor.

c. Where voltages above the specified overload limits are likely to be encountered, use the Model 952005 100:1 Voltage Divider (optional accessory). Maximum rating of the voltage divider is 1000 volts (DC + peak AC).

d. The terminated Model 952009 RF Probe is overload protected to 4 volts AC and 400 volts DC. Exceeding these limits may result in permanent damage.

2-20. Connection Recommendations.

a. The Model 952001 probe is equipped with a detachable tip and ground lead. For measurement of signals below approximately 100 MHz, this tip provides a convenient means for making both signal and ground connections.

b. For frequencies above 100 MHz, the probe tip should not be used because the series impedances of the connection will affect the voltage level at the probe and cause an error in measurement. For high impedance voltage measurements, connection should be made directly to the center contact of the RF probe, with the ground connection kept as short as possible. For matched impedance measurements, one of the various terminated adapters, tee adapter or Model 952009 Probe should be used (See Figure 2-3).

2-21. Low-Level Measurements. The instrument will provide reliable, reproducible measurements of signal levels as low as 200 microvolts. Useful indications extend down to 50 µV. Zeroing of the instrument is essential when using the lower ranges in order to achieve the specified accuracy. Zeroing is also strongly recommended for all ranges up to 30 millivolts. Refer to paragraph 2-16 for the zeroing procedure.

2-22. Temperature Effects.

a. The accuracy specifications for the instrument apply over a temperature range of 0°C to 50°C. Outside these limits, operation of the instrument is possible, but appreciable inaccuracies can be expected; however, no permanent change in probe characteristics will result from any reasonably high or low temperature exposure.

b. It should be noted that inaccuracies of measurement resulting from temperature effects may occur shortly after soldering to the RF probe tip, or measuring with the probe in the vicinity of heat sources such as resistors, heat sinks and so forth.

c. When making low-level measurements (below approximately 2 millivolts), it is important to make sure that the probe has attained a uniform temperature throughout its body. A temperature gradient between the inside and outside of the probe can generate a small thermal voltage that may add to the DC output of the detector diodes.

2-23. Hum, Noise and Spurious Pickup. When measuring low-level signals, precautions should always be taken to avoid the possibility of measurement errors resulting from hum, noise or stray RF pickup. Although all low-frequency hum and noise are attenuated at the input, unwanted high-level signals could still possibly cause errors. In some cases it may be necessary to provide extra shielding around the probe connection to reduce stray pickup. Some typical sources of spurious radiation are induction or dielectric heating units, diathermy machines and local radio transmitters.

2-24. Recorder Output. The DC output provided at the rear-panel RECORDER connector may be used to drive an XY recorder for swept measurements, or a strip chart recorder for monitoring applications. (Refer to paragraph 2-7a.)

2-25. Correction Curve for Model 952003 50Ω N Tee Adapter. When using the optional Model 952003 50Ω N Tee Adapter, the input voltage to the adapter is indicated directly on the instrument. To obtain the correct output voltage from the adapter, subtract the correction shown in Figure 1-4 from the input voltage, in dB, indicated on the instrument. Corrections are not required if the Model 952003 is terminated in 50Ω.

2-26. Correction Curve for Model 952007 75Ω N Tee Adapter. When using the optional Model 952007 75Ω N Tee Adapter, the input voltage to the adapter is indicated directly on the instrument. To obtain the correct output voltage from the adapter, subtract the correction shown in Figure 1-4 from the input voltage, in dB, indicated on the instrument. Corrections are not required if the Model 952007 is terminated in 75Ω.

2-27. MINIMUM PERFORMANCE STANDARDS.

2-28. Test Equipment Required. A 1 MHz low-impedance voltage calibration source, such as the Boonton Electronics Corporation Model 26A RF Millivoltmeter Calibrator and a DC voltmeter or oscilloscope capable of measuring 0 to +10 volts is required.

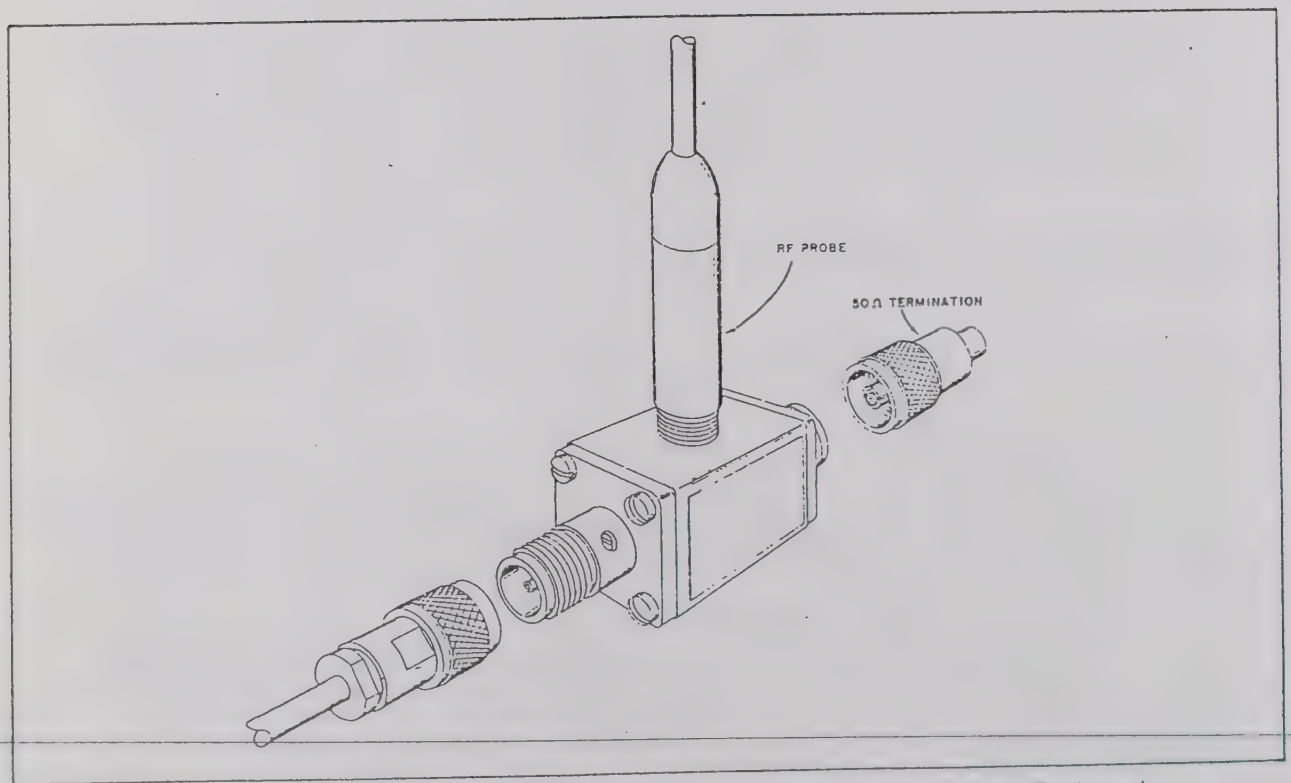


Figure 2-3 Attachment of Model 952003 50-Ohm N Tee Adapter To Model 952001 Probe and Model 952014 50-Ohm Termination.

2-28. (CONT.)

NOTE

The Model 26A RF Millivoltmeter Calibrator is designed to operate into a high impedance load, such as the Model 952001 RF Probe. If the instrument is fitted with the Model 952009 RF Sensor, which has a built in 50Ω termination, it will be necessary to modify the output circuit of the Model 26A, as follows:

a. Disconnect AC power to the Model 26A.

b. Remove the bottom cover by removing the securing screw at the rear and then sliding the cover to the rear.

c. Remove the TNC-50Ω termination from the tee adapter at the output of the calibrator.

d. Replace the cover, re-power and proceed as follows:

2-29. Preliminary Setup.

a. Turn on the instrument and calibrator and allow sufficient warmup time. If either unit had been stored at ambient temperatures substantially different from the ambient temperature at the test facility, make sure enough time is allowed for each device to reach ambient temperature.

b. Set the calibrator output to zero. Attach the channel 1 RF probe to the front panel SENSOR connector on the instrument and connect the probe input to the calibrator using an open circuit BNC Model 91-6G adapter supplied with the calibrator.

c. Key in the following measurement parameters through the instrument keyboard:

1 SELECT CHNL
1 PROBE (SENS)
MODE mV
0 REF LEVEL dB

NOTE

Maintain the measurement parameters specified above for each of the following tests unless specifically directed otherwise.

2-30. Automatic Zero Function Test. To check the automatic zeroing function of the instrument, proceed as follows:

a. Ascertain that the signal input to the probe is zero. (Press the white 0 key on the calibrator.)

b. Press the ZERO key on the instrument and ascertain that the following results are obtained:

1. The logic signal level at pin 4 of rear-panel connector P3 should switch from a logic low to a logic high when the ZERO key is pressed. It should remain high throughout the zeroing period and it should return to a logic low at the end of the zeroing period.

2. The instrument display should display cccc for approximately 18 seconds after the ZERO key is pressed. At the end of the zeroing period, the display should show cc3 for all dB modes, or a residual reading for the mV mode.

NOTE

In the mV mode, the residual reading after zeroing is composed of random noise and residual offsets. It should ideally show plus and minus excursions of less than 100 counts.

2-31. **Autoranging Mode Test.** To check the autoranging function of the instrument, set the calibrator to each of the values listed below and ascertain that the instrument display agrees with each input level within ±2%:

3000 mV
1000 mV
300 mV
100 mV
30 mV
10 mV
3 mV
1 mV

2-32. **Basic Instrument Accuracy Test.** To check the basic accuracy of the instrument, proceed as follows:

a. With zero input to the probe (white 0 button on the calibrator pressed), zero the instrument by pressing the ZERO key.

b. Press the MODE mV key after zeroing has been completed.

c. Set the output level of the calibrator to each of the following full-scale levels in succession and ascertain that the instrument display agrees within the accuracy shown:

Full Scale Values	
Voltage Levels	Accuracy of Indication
3000 mV	±1% ±1 count ±calibrator uncertainty
1000 mV	±1% ±1 count ±calibrator uncertainty
300 mV	±1% ±1 count ±calibrator uncertainty
100 mV	±1% ±1 count ±calibrator uncertainty
30 mV	±1% ±1 count ±calibrator uncertainty
10 mV	±1% ±1 count ±calibrator uncertainty
3 mV	±1% ±1 count ±calibrator uncertainty
1 mV	±2% ±2 counts ±calibrator uncertainty

d. Set the output level of the calibrator to 1000 millivolts. Then, set the output level of the calibrator to each of the following values in succession and ascertain that the instrument display agrees with the applied level within the tolerance shown.

Downscale Values	
Voltage Levels	Accuracy of Indication
1000 mV	±1% ±1 count ±calibrator uncertainty
900 mV	±1% ±1 count ±calibrator uncertainty
800 mV	±1% ±1 count ±calibrator uncertainty
700 mV	±1% ±1 count ±calibrator uncertainty
600 mV	±1% ±1 count ±calibrator uncertainty
500 mV	±1% ±1 count ±calibrator uncertainty
400 mV	±1% ±1 count ±calibrator uncertainty
300 mV	±1% ±1 count ±calibrator uncertainty

2-33. **dB Mode Check.** To check the dB modes of operation, proceed as follows:

a. Press the following keys:

1 (or 2) SELECT CHNL
MODE mV
50 SELECT Z_o
0 REF LEVEL dB

b. Set the calibrator output to 1000 mV. The indication on the instrument display should be 1000 mV ±2%.

c. Press the MODE dBmV key. The indication on the instrument display should be 60.00 ±0.18 dBmV.

d. Press the MODE dBV key. The indication on the instrument display should be 00.00 ±0.18 dBV.

e. Press the MODE dBm key. The indication on the instrument display should be 13.01 ±0.18 dBm.

2-34. **dB Reference Level Function Test.** To check the dB reference level function of the instrument, proceed as follows:

a. Set the output level of the calibrator to 1000 mV.

b. Press the MODE dBm key and ascertain that the instrument display indicates approximately 13 dB.

c. Enter a +13 dB reference level by pressing the following keys:

1
3
REF LEVEL dB

d. Ascertain that the instrument display now indicates approximately 0 dBr. Both the dBm annunciator and the dBr annunciator should be lighted.

e. Reset the instrument to indicate dBm by pressing the following keys:

0 (or CLR)
REF LEVEL dB

f. Ascertain that the instrument display again indicates approximately 13 dB. The dBm annunciator should be lighted and the dBr annunciator should be off.

SECTION III

THEORY OF OPERATION

3-1. GENERAL.

3-2. The instrument is a general purpose RF voltmeter capable of measuring RF voltage levels from 200 microvolts to 3 volts. It is designed to operate with Boonton Electronics Corporation Model 952001 and 952009 RF probes. The lowest usable frequency for calibrated measurements is 10 kHz; the highest frequency is 2.5 GHz. Useful response for relative measurements can be obtained to beyond 8 GHz.

3-3. The instrument is completely solid-state and employs a microprocessor for versatility and convenience of use. The microprocessor is controlled by a permanently stored internal program. Desired operating parameters are entered by means of a front-panel keyboard. Use of a microprocessor permits automation of numerous functions, such as zeroing, range selection, unit conversion, dB limit testing, relative dB measurements, etc. Measured values are displayed directly on a 4-digit LED display in terms of V, mV, dBmV, dBV, dBm, dBw or dBr (relative dB). Annunciators associated with the display indicate the unit of measurement. An analog meter is also provided for relative voltage measurements; this feature simplifies such operations as nulling and peaking. A DC voltage that is proportional to the measured value is available at a rear-panel connector.

3-4. OVERALL BLOCK DIAGRAM. (See Figure 3-1.)

3-5. **Probe.** RF levels to be measured are applied to an external probe, which connects to the CHANNEL connector on the front panel of the instrument. The probes convert the applied RF voltage to a DC voltage. The DC voltage is supplied to the input module of the instrument.

3-6. **Input Module.** The input module receives the DC voltage developed by the probe. Operating under control of the control module, the input module converts the DC voltage to an AC voltage, amplifies this AC voltage, converts it to an analog DC voltage and converts this to a digital signal. If the autoranging function of the instrument has been selected, the gains of the amplifiers in the input module are adjusted automatically by the control module to accommodate any voltage level within the range of the instrument. The digital output signal of the input module is supplied to the control module for additional processing; an analog DC output signal is developed from the digital signal and this analog DC signal is applied to the analog meter in the display module for relative voltage measurements and to a rear-panel connector for application to a peripheral recorder.

3-7. **Control Module.** The control module consists primarily of a preprogrammed microprocessor. The microprocessor accepts and stores measurement parameter commands entered through the front panel keyboard, and controls operation of the internal circuits of the instrument in accordance with its program and keyed-in commands. The microprocessor performs measurement value corrections based on stored zero corrections and stored gain and range linearization factors, unit conversions based on selected measurement modes and dB limit determination. The microprocessor also performs key-initiated automatic zeroing. The processed digital signal, which defines the final measurement value, is applied to a data bus and to the display module.

3-8. **Display Module.** The display module contains the keyboard and LED display circuits. Parameters to be used for measurements can be entered at any time through the keyboard and can also be recalled for checking. Keyed-in values are read and stored by the microprocessor and keyed-in numerical values are shown on the display during parameter entry. Computed voltage levels are processed by the microprocessor in accordance with the keyed-in data; the digital values representing the final computer measurement values are decoded by the display module circuits to produce a direct LED readout of measured values and to activate the proper annunciators.

3-9. **Power Supply Module.** The power supply module provides all DC voltages required for operation of the internal circuits of the instrument. It also provides a reset signal to the control module when power is applied and an interrupt signal if an undervoltage condition is detected. The power supply module can be powered from a 100, 120, 220 or 240 volt, 50 to 400 Hz, AC power source.

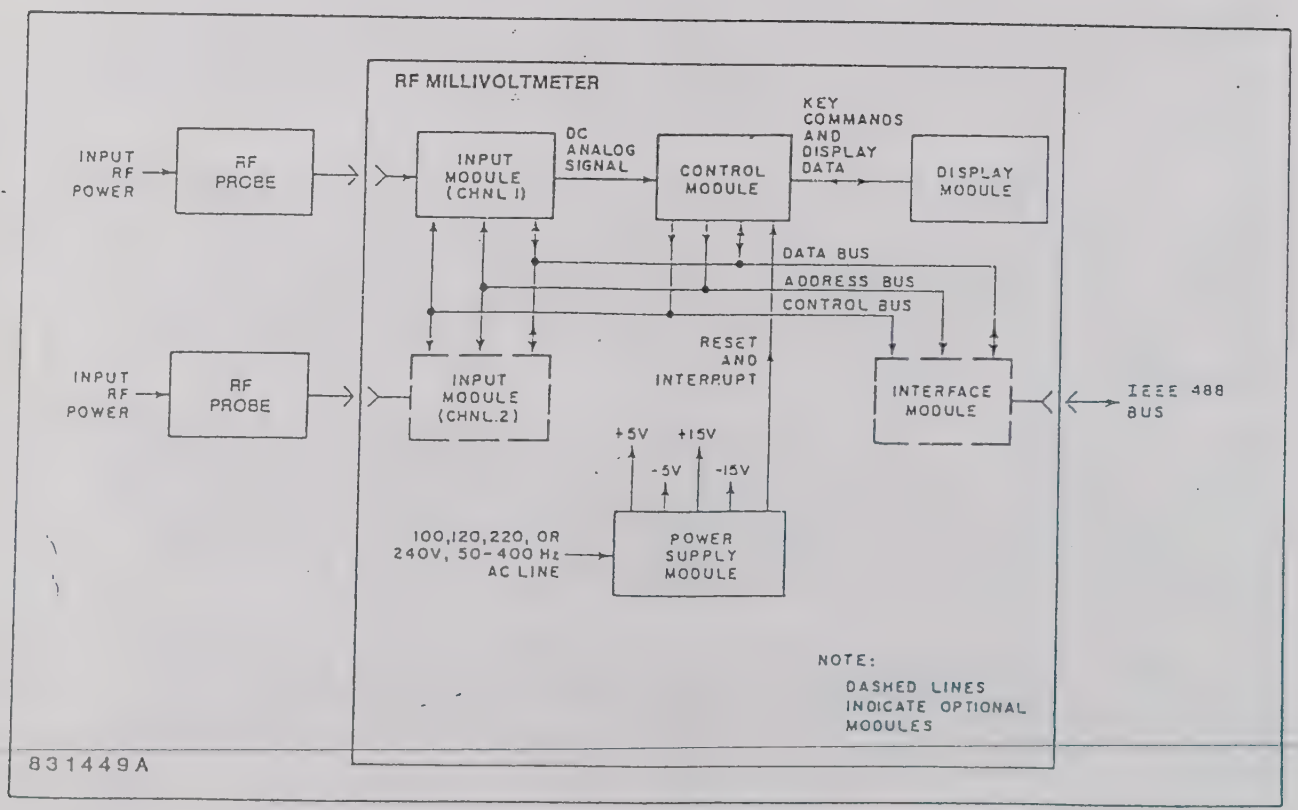


Figure 3-1 Overall Block Diagram

3-10. Optional Modules. A variety of standard options is available to increase further the versatility of the instrument. Two of these optional modules are included in Figure 3-1.

a. A second input module (option 9200B-03) can be added to the instrument to permit measurement of voltage levels at two locations without the need for repeated switching of probe connections. The input connector for this optional module is located on the rear panel of the instrument. The second input module also permits display of the difference between the levels at the two locations, expressed in dB.

b. The interface module (option 9200B-01Ø) provides an IEEE 488 bus interface for remote control of instrument operation and for remote access to measured values.

3-11. DETAILED THEORY OF OPERATION, PROBE CIRCUITS.

3-12. The RF probes used with the instrument convert RF to DC. The RF voltage applied to the probes is rectified by a full-wave detector that employs factory-selected diodes with special characteristics, including low capacitance and controlled thermal offsets. The resulting DC voltage is a function of the applied RF voltage.

3-13. A full-wave detector, unlike a single-diode detector, permits measurement of highly asymmetric waveforms without substantial error. When a voltage of asymmetric waveform if impressed on a single-diode detector circuit, whether or not the portion of the waveform that turn on the diode is restricted to the square-law region of the diode's characteristic, the recovered DC voltage is dependent upon the phase of the input voltage. Consider a positive pulse of low duty cycle applied to the anode of a diode detector. The recovered DC voltage is a function of the polarity, amplitude and duration of the pulse. If the pulse is inverted, it drives the diode into a reverse bias condition and the recovered DC voltage is zero. A full-wave detector circuit, on the other hand, yields an equal amount of DC irrespective of the polarity of the input pulse. The average voltage of a pulse obviously does not depend upon the phase of the pulse. The response of a single diode detector, square law characteristic notwithstanding, cannot reflect this; a full-wave detector circuit does.

3-14. Probe response is true RMS for inputs below 30 mV. Above this voltage level, the probe response gradually changes, approaching peak-to-peak at the higher voltage levels, however, the voltage data is digitally shaped in the instrument to indicate RMS voltage, provided that the input is reasonably sinusoidal as is the case with CW and FM signals. The body of the probe has been designed and fabricated to eliminate any cavity resonance effects within the calibrated frequency range and to minimize noise. The DC output voltage from the probe is applied to the CHANNEL connector of the instrument through a low-noise probe cable.

3-15. DETAILED THEORY OF OPERATION, INPUT P.C. BOARD CIRCUITS. (See Figure 3-2)

3-16. The input printed circuit board receives from the probe a DC voltage that is a function of the RF voltage level being measured. Under control of the control board circuits, it provides amplification and signal processing required to develop an analog DC voltage and a digital signal that are both proportional to the input RF voltage level. The input DC voltage from the probe is balanced in form and may vary from microvolts to volts, depending upon the input RF voltage level. The input printed circuit board must provide amplification with a wide range of gain, low offset voltage and low noise; therefore, the input DC voltage is converted to an AC voltage which is amplified and the amplified AC voltage is converted to a DC analog signal and to a digital signal.

3-17. The input DC voltage is converted to an AC voltage by a chopper module, which plugs in to the input printed circuit board. The chopper is composed of solid-state switches IC1a through IC1d in a balanced arrangement, operating at a frequency of approximately 94 Hz to minimize AC line and line-related component interaction. The chopper drive signal is derived from the output of an astable multivibrator, which is completely independent of line frequency. The use of a solid-state chopper eliminates many of the problems, such as contact wear and contamination, associated with electromechanical choppers. The chopper supplies a balanced AC signal of approximately 94 Hz to the input amplifier.

3-18. Amplification of the balanced 94-Hz AC signal from the chopper is accomplished by an input amplifier composed of low-noise operational amplifiers A5, A6 and A7. A balanced arrangement with degenerative feedback for stabilization and gain control is employed. The input AC signal is amplified by 500, 50,

3-18. (CONT.)

5 or 0.5, depending upon the instrument range. Demultiplexer IC6, under control of the control printed circuit board, adjust the degenerative feedback in accordance with the range selected by the microprocessor to provide the required gain switching. An attenuator at the output of the input amplifier provides attenuation of 5 for the highest range only; on all other ranges its attenuation is 1. This attenuator is switched into the circuit on the highest range through solid-state switches IC10a, IC9b and IC9c. Demultiplexer IC13 decodes digital signals that define the range and activates the solid-state switches on the highest instrument range.

3-19. The amplified 94 Hz signal is converted to a DC analog signal by means of a demodulator circuit that operates in synchronism with the chopper. The demodulator consists essentially of a sample-and-hold switch, composed of solid-state switches IC10b and IC10c and associated circuitry. Switches IC10b and IC10c are controlled by the 94 Hz drive signals from flip-flops IC8a and IC8b. The sampling point and period of the sample-and-hold circuit have been chosen to minimize switching products and noise and to vary signal averaging in accordance with the signal level. Switch IC9a adjusts operating parameters automatically in accordance with the instrument range; it is activated through gates IC11b and IC11c and demultiplexer IC13 on the four higher ranges.

3-20. The DC output voltage of the sample-and-hold circuit is amplified by integrated circuits A8, IC14, A9 and associated circuitry. Integrated circuit IC14 is a demultiplexer that decodes microprocessor-supplied digital signals that define the selected range and adjusts an attenuator circuit accordingly; the gain of the amplifier is 125, 12.5 or 1.25, depending upon the selected range. The full-scale output voltage of the amplifier is 2.5 volts nominal on each range.

3-21. The output voltage of integrated circuit A9 is usually unipolar and positive, however, during automatic zeroing, it may be positive or negative, depending upon small DC offsets. Because some of the following circuits operate only with unipolar signals, a polarity switch is required. This polarity switch, which consists of solid-state switches IC3b and IC3c, operates under control of the microprocessor on the control printed circuit board, which tests for polarity. The DC voltage is routed through the polarity switch to the appropriate input of operational amplifier A3 so that the DC output from this amplifier is always negative. This negative output voltage is applied to a comparator circuit.

3-22. Comparator A2 operates in conjunction with the microprocessor on the control printed circuit board and D/A converter IC2 to convert the DC output signal of amplifier A3, which is proportional to the input RF voltage, to a digital signal that can be processed by the microprocessor. D/A converter IC2 is supplied with successive half-level digital signals (full-scale/2, full-scale/4, etc.) by the microprocessor. D/A converter IC2 converts these digital signals to a DC analog voltage that is supplied through amplifier A1 to comparator A2, where it is compared with the DC signal from amplifier A3. The difference signal from comparator A2 is supplied to the microprocessor through interface IC1 so that the microprocessor can monitor the results of the comparison and adjust the digital signal accordingly. The digital signal is adjusted by the microprocessor until the two input signals applied to comparator A2 are equal. The resulting digital signal then defines the DC level being measured. This digital signal is then processed (zero correction, unit conversion, etc.) by the microprocessor before application to the LED display circuits of the instrument.

3-23. After the digital signal has been fully processed by the microprocessor, it is supplied by the microprocessor to D/A converter IC2, which now converts the processed digital signal to a corresponding DC analog voltage that is used to drive the front-panel meter and the recorder output of the instrument. This DC analog voltage from D/A converter IC2 is supplied through amplifier A1 to sample-and-hold switch IC3a, which is closed at this time by a control signal from the microprocessor. The analog DC voltage from the sample-and-hold circuit is applied to the front-panel meter and the recorder output.

3-24. All interfacing between the input printed circuit board and the microprocessor is accomplished through interface IC1, an input/output device that operates under control of the microprocessor. When signal $\overline{RD}$ is activated by the microprocessor, data is transferred from the input printed circuit board to the microprocessor, provided that signal $\overline{CS}$ to interface IC1 is also active; when signals $\overline{WR}$ and $\overline{CS}$ are both activated by the microprocessor, data is transferred

3-24. (CONT.)

from the microprocessor to the input printed circuit board. Data flows between the input printed circuit board and the microprocessor over the eight-line bidirectional data bus. Routing of data through the interface is controlled by the address signals supplied to the interface by the microprocessor.

3-25. DETAILED THEORY OF OPERATION, CONTROL P.C. BOARD CIRCUITS. (See Figure 3-3.)

3-26. Operation of the instrument is controlled by a microprocessor on the control printed circuit board. The control printed circuit board is organized around a central processing unit (CPU), associated memories, input/output ports and a 40-line bus. A stored program, in conjunction with key-entered commands, enables the microprocessor to perform a variety of functions, including the following:

a. Analog to digital conversion
b. Zero determination
c. Zero correction
d. Ranging
e. Signal processing
f. Binary to BCD conversion
g. dB conversion
h. dB reference conversion
i. dB limit testing

3-27. Integrated circuit IC3 is the microprocessor CPU. It is an 8-bit unit that operates at a clock frequency of 2 MHz, generated by integrated circuits IC1a through IC1c and associated circuitry. The operating program for the microprocessor is stored in integrated circuits IC6 and IC7, which are programmable read-only memories (PROMs). RAM IC8 provides temporary storage of data during operation of the instrument. It also stores certain measurement parameters such as probe data, key-entered parameters, etc. Lithium-type battery BT1, which has an anticipated life of 10 years, supplies power to RAM IC8 during power-down of the instrument to enable retention of data in memory. During normal operation, RAM IC8 is powered by transistor Q1. Integrated circuit IC16 is an I/O port which interfaces with the following:

a. An 8-bit switch used to set the mode of operation, number of channels and number of probes.

b. A test socket (J3) used in signature analysis.

c. A connector (P3) for output of status information.

3-28. The CPU receives and transmits data over an 8-line data bus. A 15-line bus is used for addressing and a control bus is used for various control functions. When the instrument is turned off, signal $\overline{\text{RESET}}$ is activated by the power supply circuits and the microprocessor is reset to the start of the operating program; when the instrument is next turned on and DC voltages have reached the correct operating levels, the $\overline{\text{RESET}}$ signal is deactivated by the power supply circuits and the microprocessor begins to execute the stored program instructions. Instructions are retrieved from storage by the CPU in accordance with the address code developed at its output. Decoder IC4 enables the appropriate PROM (IC6 or IC7) and the instruction contained in the memory location defined by the address on address lines A0 through A11 is read and transmitted to the CPU over the data bus. The CPU then executes this instruction.

3-29. During the measurement process, the CPU must retrieve data from storage and from the input and display printed circuit boards; it must store temporary calculation values; and it must output data to the input and display printed circuit boards. To retrieve data from memory, the storage device and memory location are defined by the address supplied by the CPU and signals $\overline{\text{MREQ}}$ and $\overline{\text{RD}}$ are activated. Integrated circuit IC4 decodes three of the address bits to activate signal $\overline{\text{CS}}$ at RAM IC8 through gates IC9a and IC9c. Signal OE at RAM IC8 is activated through gate IC15d and data stored at the location specified by the remaining address bits are transmitted over the data bus to the CPU or to other circuits connected to the data bus. To access data developed by circuits outside the control printed circuit board, the CPU activates signals $\overline{\text{IORQ}}$ and $\overline{\text{RD}}$ along with the appropriate address lines. Decoder IC14 decodes three address bits to develop enabling signal $\overline{\text{CS}}$ for interface IC16, integrated circuit IC18, or interface IC1 on the input printed circuit board, as specified by the three address bits; and gate IC15b activates signal $\overline{\text{RD}}$ for the read function. If integrated circuit IC18 is enabled, keyed-in commands from the display circuit

3-29. (CONT.)

board, which had been stored in integrated circuit IC18, are transmitted over the data bus. If integrated circuit IC16 is enabled, input data from connector J3, bit switch S1 or power supply connector P4, as determined by address bits A0 and A1, is supplied through interface IC16 to the data bus. If interface IC1 on the input printed circuit board is enabled, data generated on the input printed circuit board is transmitted over the data bus through interface IC1.

3-30. To write data into memory, the CPU activates signal $\overline{WR}$ and the address lines that define the storage device and storage location. Decoder IC4 decodes three address bits to enable signal $\overline{CS}$ at RAM IC8, signal $\overline{WR}$ enables the write function of RAM IC8 through inverter IC1d and gate IC9b, and data on the data bus is written into memory at the location specified by the remaining address lines. To output data to circuits outside the control printed circuit board, signal $\overline{IORQ}$ is activated by the CPU in addition to the previously mentioned signals. Signals $\overline{IORQ}$ and $\overline{WR}$ activate the write enable signal to the device defined by the address bits. Decoder IC14 decodes three address bits to select the appropriate device (interface IC16, interface IC18 or interface IC1 on the input printed circuit board). Data on the data bus is then transferred to the selected device. If interface IC16 is selected, this data is transferred through interface IC16 to connector P3 or J3, as determined by address bits A0 and A1. The output to connector P3 consists of dB out-of-limit signals and an input-disconnect signal, which is activated when the automatic zeroing function is initiated. The output data on connector J3 is used in signature analysis checks. If interface IC18 is selected, the data on the data bus are written into storage in interface IC18 for application to the display printed circuit board. These data are subsequently clocked out of storage to activate the LED display and annunciators on the display printed circuit board. If interface IC1 on the input printed circuit board is selected, data on the data bus are transferred through the interface to control various functions on the input printed circuit board.

3-31. Connector J1 is included in the data bus on the control printed circuit board to facilitate signature analysis checks of the microprocessor circuits. When connector J1 is pulled out, the data bus is disconnected from the CPU and the CPU executes successive NOPs for free-running signature analysis checks.

3-32. The CPU receives two control signals directly from the power supply printed circuit board. If the power supply voltage should drop during operation, or on equipment turn-off, signal $\overline{NMI}$ is activated by the power supply circuits; the CPU, on receipt of this signal, activates signal $\overline{HALT}$, thereby halting further execution of the program. Signal $\overline{HALT}$ is applied back to the power supply printed circuit board, where it latches signal $\overline{RESET}$ in the active state. Signal $\overline{RESET}$, in turn, causes the microprocessor to return to the starting point of the program. When the power supply voltage rises to a level approximately 150 millivolts below its nominal value, either as a result of correction of the undervoltage condition or of power turn-on, signal $\overline{RESET}$ is deactivated to permit execution of the stored program by the microprocessor.

3-33. DETAILED THEORY OF OPERATION, DISPLAY P.C. BOARD CIRCUITS. (See Figure 3-4.)

3-34. The display printed circuit board contains the instrument LED display, analog meter, annunciators, keyboard and control circuits for these items. It interfaces directly with the control printed circuit board. When any keyboard key is pressed, the microprocessor on the control printed circuit board interrupts the normal measurement process and accepts and stores the key-entered commands; the microprocessor also supplies digital data to the display printed circuit board to cause keyed-in numerical values to appear on the LED display. The microprocessor resumes the normal measurement process when any of the terminator keys (LIMITS dB, SELECT REF LEVEL dB) is pressed. Upon completion of the measurement by the microprocessor, measurement values are supplied to the display printed circuit board.

3-35. Operation of the display printed circuit board is controlled by the microprocessor through integrated circuit IC18 on the control printed circuit board, which provides the following functions:

a. It provides a RAM for storage of microprocessor output data to the display printed circuit board.

b. It provides a first-in, first-out RAM which accepts and stores input information (up to 8 key commands) from the display printed circuit board.

c. It provides scan signals for both the LED display and the keyboard.

3-36. The LED display consists of four 7-segment displays, which provide a display capacity of four digits with decimal points and a fifth display which is capable of displaying a minus sign. Each display consists of individual anodes for each segment that makes up the display, the decimal point and a common cathode. The character that appears on the display is determined by the activated anodes at the time that the common cathode is scanned. The individual displays and the associated annunciators are scanned in sequence. The display duty cycle is 12.5%; that is, each digit or annunciator of the instrument is on 12.5% of the time.

3-37. Digital information for the LED display and annunciators is developed by the microprocessor and is stored in the output RAM contained in integrated circuit IC18 on the control printed circuit board. Digital information that defines display and annunciator row selection is supplied to 8-channel demultiplexer IC2. The output lines of demultiplexer IC2 are activated in sequence, based on the input digital codes. The signal on the active output line of demultiplexer IC2 is applied through resistive network IC5 to display driver IC7 and the display driver supplies driving power for the corresponding display and the corresponding annunciator row. At the same time, digital data that define the display segments and annunciators that are to be activated are supplied to decoder IC1. The binary-coded input is decoded by decoder IC1 and the output lines of the decoder are activated in accordance with this decode. The outputs of the decoder activate the individual anodes of the selected display and the individual annunciators in the active annunciator row, thereby providing the appropriate instrument display. A decimal-point signal is applied through transistor Q1, when appropriate, to cause a decimal point to be displayed to the right of the character on the active display.

3-38. Demultiplexer IC2 also supplies scanning signals to the keyboard. As each of its first five output lines is activated in sequence, a scan signal is applied to an individual row of the keyboard through an inverter. If any key in the row being scanned is pressed, a signal is supplied to one of the column output lines to the RAM in integrated circuit IC18 on the control printed circuit board and the key command is stored in the RAM. Key selection is defined by a combination of the row scan signal and the column output line. The RAM can store up to a maximum of eight key commands and it delivers this stored information to the microprocessor when it is read. Actuation of more than eight key commands without a read causes the RAM to be cleared.

3-39. Analog DC voltage proportional to the measured RF voltage level is supplied from the control printed circuit board to the front-panel meter to provide a relative indication of measured RF voltage for peaking and nulling applications. The DC analog voltage is also supplied to rear-panel connector P1. This signal can be used to drive an external recorder.

3-40. DETAILED THEORY OF OPERATION, POWER SUPPLY CIRCUITS. (See Figure 3-5.)

3-41. Power supply printed circuit board A7 performs the following functions:

a. Converts 100, 120, 220 or 240 volt, 50 to 400 Hz, AC line power to +5, +5.2, -5, +15 and -15 volt DC for system operation.

b. Generates a power-up signal for the microprocessor when supply voltage levels reach the proper values for system operation.

c. Activates an interrupt signal to the microprocessor when supply voltage levels drop to values too low for reliable operation.

3-42. Input AC line power is supplied to the primary of power transformer T1 on the main chassis through fuse F1, LINE switch S1 and a voltage-selector printed circuit card. The voltage-selector printed circuit card provides a convenient way to change the primary winding connections of power transformer T1 to accommodate the various AC line voltages.

3-43. Power transformer T1 steps down the AC line voltage. Two separate secondary windings drive bridge rectifiers CR1 and CR2. The DC output voltage of rectifier CR1 is filtered by capacitors C1 and C2, and is then supplied to regulators IC2 and IC3, which develop +15 volts and -15 volts DC, respectively. A regulated -5 volt output is derived from the regulated -15 volt supply by regulator IC5. The DC voltage developed by rectifier CR2 is filtered by capacitor C3 and drives regulator IC4 to develop the +5.2 volt DC output. Potentiometer R5 provides means for adjusting the +5.2 volt output.

3-44. The raw +15 volt DC supply also drives regulator IC1, which produces +5 volts to power integrated circuits A1 and IC6 and generate a DC reference voltage at the junction of resistors R7 and R8. Comparator A1a monitors the output voltage of the +5.2-volts regulated supply to develop a power-up signal on turn-on and an interrupt signal for undervoltage or power-down conditions. When the instrument is turned on, comparator A1a develops a positive output pulse when the output voltage of the +5.2-volts regulated supply reaches a level approximately 150 millivolts below the nominal output voltage. This positive pulse clocks flip-flop IC6 to deactivate signal $\overline{\text{RESET}}$ to the microprocessor on the control printed circuit board. When the output voltage of the +5.2-volts regulated supply drops below the reliable usable level during instrument operation or during instrument shutdown, comparator A1a switches its output level to a logic low, thereby activating signal $\overline{\text{NMI}}$ to the microprocessor. The microprocessor then activates signal $\overline{\text{HALT}}$, which reset flip-flop IC6, thereby latching signal $\overline{\text{RESET}}$ low to ensure resetting of the microprocessor to the start of its program.

SECTION IV

MAINTENANCE

4-1. GENERAL.

4-2. This section contains maintenance instructions for the instrument. Included are a list of required test equipment, trouble localization procedure, instrument adjustment procedures and probe calibration procedures. Minimum performance checks are included in Section II; these checks should be performed whenever there is any doubt about instrument performance.

4-3. TEST EQUIPMENT REQUIRED.

4-4. Table 4-1 lists test equipment required for maintenance of the instrument. Test equipment of equal capability may be substituted for any listed item except the Model 5004A signature analyzer, unless it is known that the substitute signature analyzer agrees completely with the Model 5004A and the Model 2500 Range Calibrator.

NOTE

Calibration Tape and Diagnostic ROM Kit contains a calibration tape designed for use with the HP9825 Controller. It can be used for testing of the GPIB, for printing out the contents of non-volatile memory and for DC and AC calibration of the instrument. Instructions for use of the calibration tape are included with the kit.

4-5. TROUBLESHOOTING CONCEPT.

4-6. The instrument employs both analog and digital circuitry. The digital portion uses a microprocessor in a bus-oriented system. DC and AC measuring instruments such as voltmeters and oscilloscopes have been the traditional test instruments for electronic instrument maintenance; however, in a microprocessor-based, bus-oriented system, such test equipment, while still useful and necessary, leaves much to be desired. With such test equipment alone, troubleshooting in a bus-oriented system is extremely tedious and time-consuming, if not impossible. A technique called signature analysis has been devised to deal with microprocessor-based systems. The troubleshooting procedures in this section are based on signature analysis techniques.

4-7. SIGNATURE ANALYSIS.

4-8. A complete discussion of signature analysis is beyond the scope of this manual, however, a brief discussion will aid in maintenance of the instrument. Long, complex data streams are present in microprocessor-based, bus-oriented systems. In signature analysis, with the system operating at normal speed, these data streams are compressed into concise, easy-to-interpret readouts (signatures) measured at pertinent nodes. By choosing or generating appropriate measuring periods or windows, these signatures become unique; one and only one signature occurs at each node if operation is normal. Using signature analysis, it is possible to proceed through the instrument in an orderly fashion until a faulty signature is obtained. Generally, at that point, it is possible to identify one component as the most probable cause of the malfunction.

TABLE 4-1. TEST EQUIPMENT LIST

Nomenclature	Model
Digital Multimeter	Data Precision 1450
Oscilloscope	Hewlett-Packard 1740A
RF Millivoltmeter Calibrator	Boonton Electronics 26A
Signature Analyzer	Hewlett-Packard 5004A

TABLE 4-1. TEST EQUIPMENT LIST (CONT.)	
Calibration Tape and Diagnostic ROM Kit	Boonton Electronics
Range Calibrator	Boonton Electronics 2500
NOTE The following additional items are required only for RF probe SWR and frequency response checks.	
Signal Generator:	
125 kHz to 175 MHz	Boonton Electronics 103C or 103D
450 kHz to 520 MHz	Boonton Electronics 102E or 102F
10 MHz to 1400 MHz	Wavetek Model 2001
Slotted Line	General Radio 900 LB
Detector	General Radio 1241 or Boonton Electronics 9200
Power Splitter	Weinschel Model 1870A or Hewlett-Packard 11850A
Calibrated RF Microwattmeter	Boonton Electronics 4200
Sweep Generator	Wavetek 2001
SWR Autotester	Wiltron 63N50
Oscilloscope	Tektronix 5110 (with two 5A20 vertical amplifiers)
Standard 1.2:1 Mismatch Termination	Weinschel M1410-1.2

4-9. Signature analysis checks are of two basic types: "free running" and "stimulated" or programmed. In free-running checks, the data bus between the microprocessor and the system is opened and an instruction that will cause the microprocessor to free-run is forced. The microprocessor then runs through its address field repeatedly. Free-running checks may be used to check the following:

a. Microprocessor address output

b. Memory select decoding

c. I/O select decoding

d. ROM program

4-10. In the stimulated mode, the data bus between the microprocessor and the system bus is left intact and programs provided in a special ROM are invoked to conduct the desired tests. In this instrument, the stimulated mode is used to check the following:

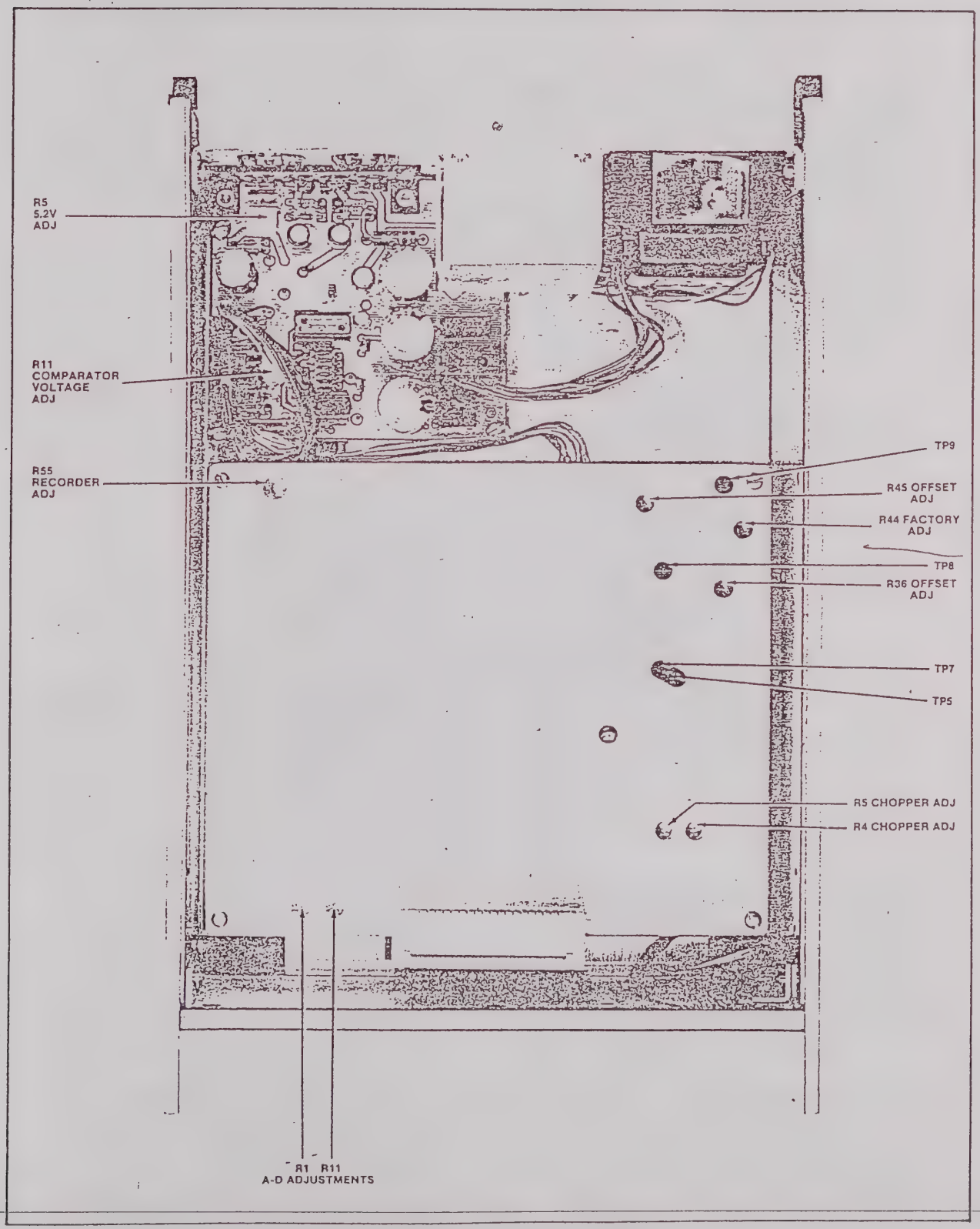


Figure 4-1 Location of Major Assemblies (Sheet 1 of 2)

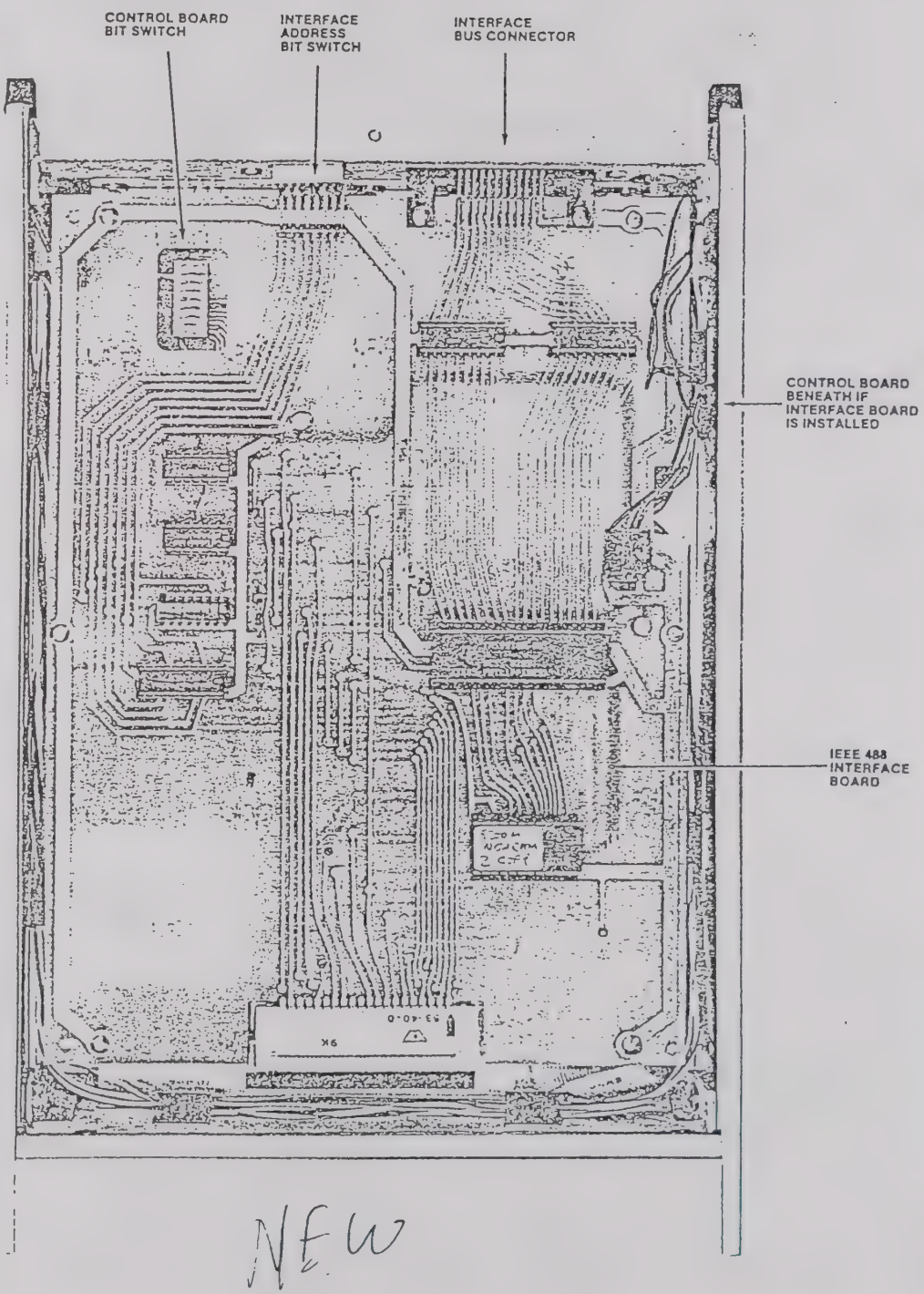

CONTROL BOARD BIT SWITCH
INTERFACE ADDRESS BIT SWITCH
INTERFACE BUS CONNECTOR
CONTROL BOARD BENEATH IF INTERFACE BOARD IS INSTALLED
IEEE 488 INTERFACE BOARD
NEW

Figure 4-1 Location of Major Assemblies (Sheet 2 of 2)

4-10. (CONT.)

a. RAM operation

b. Display functions and scanning

c. Keyboard

d. I/O ports

4-11. In this instrument, programmed signature analysis tests are activated by setting a bit switch, located at the rear of the control printed circuit board, to the number associated with the particular test. In using signature analysis, free-running tests should be performed first to ascertain that the microprocessor is putting out a normal address field, that the memory and I/O decoding is correct and that the ROM contents are normal. When correct signatures have been obtained for all free-running tests, the programmed tests may be performed.

4-12. The signature analysis technique is applicable only to the digital section of the instrument. Some sections of the instrument employ both analog and digital circuits. The input module, for example, receives a DC analog signal, amplifies the analog signal and converts it to a digital signal; the power supply uses both digital and analog circuitry to develop the voltages necessary for instrument operation. The discussion of these hybrid sections in Section III of this manual will be helpful in maintenance and servicing.

4-13. TROUBLE LOCALIZATION.

4-14. Gaining Access to Internal Components. To gain access to internal components of the instrument for maintenance or adjustment, remove the top and bottom covers by removing the securing screws at the rear of each cover and then sliding the cover to the rear. Figure 4-1 shows the location of major assemblies. To gain access to these assemblies, proceed as follows:

a. Input Module. To gain access to parts on the input module, remove four screws (one in each corner) and lift off the cover.

b. Display Module. To gain access to the display module, remove the top and bottom covers, then remove the four screws that attach the front top and bottom trim strips, and remove the top and bottom trim strips and the front panels.

4-15. Visual Inspection. With the instrument covers removed, inspect all assemblies for foreign material, unseated integrated circuits, transistors or connectors for broken leads, scorched components, loose screws and any other evidence of electrical or mechanical malfunction.

4-16. Use of Block Diagrams. By studying the detailed theory of operation in Section III together with the associated block diagrams, it may be possible to isolate the cause of an instrument malfunction to a particular block.

4-17. Systematic Troubleshooting. If visual inspection and block diagram analysis do not localize the source of an instrument malfunction, proceed with module troubleshooting as follows:

a. Power Supply. With normal input power applied to the instrument, check the power supply output voltages at each module power connector. Correct power supply voltages are shown on the applicable schematic diagrams. If an abnormal voltage is encountered, disconnect the module connector from the module and note whether the power supply output voltage becomes normal; if it does, the problem is probably not in the power supply but in the disconnected module. If, on the other hand, the abnormal voltage condition remains, work backward through the power supply circuits, comparing voltages with those shown on the power supply printed circuit board schematic diagram (Figure 6-6). By analyzing abnormal indications, it should be possible to localize the problem to one or more components in the power supply.

b. Input Module. With a 700 mV signal applied to the probe, compare waveforms and voltages with those shown in Figure 4-2. Correct indications will essentially eliminate the input module as the source of an instrument malfunction; however, incorrect indications will not necessarily localize the problem to the input module because the input module depends on proper operation of the control module for such functions as ranging, analog-to-digital conversion and recorder and meter output. If incorrect indications are obtained, localization of the problem using an oscilloscope and digital voltmeter may be a long and tedious process; a simpler approach may be to proceed with signature analysis.

4-17. (CONT.)

c. Display Module. Proper operation of the display module is generally self-evident. Incorrect operation does not necessarily mean that the problem is in the display module; the control module may be malfunctioning. The simplest and quickest way to check the display module is by performing the visual and signature analysis checks specified in paragraph 4-20.

d. Control Module. If normal indications are obtained in checking the power supply, input and display modules of a malfunctioning instrument, the problem must be in the control module; however, it is very unlikely that this situation will occur because it is virtually impossible for the input and display modules to operate properly if the control module is malfunctioning. Signature analysis is the best way to localize a problem in the control module.

4-18. SIGNATURE ANALYSIS FREE-RUNNING TEST PROCEDURES.

4-19. To make free-running signature analysis tests, proceed as follows:

CAUTION

Make certain that power is off before attempting to perform steps a, b and f of the following procedure. Failure to observe this caution may result in the loss or destruction of data stored in the non-volatile RAM.

NOTE

Prior to any signature analysis checks, note and record the settings of bit switch (Figure 4-3). Restore these switch settings upon completion of the signature analysis checks.

a. With power off, remove the data bus connector P1 on the control printed circuit board from socket J1 and disconnect jumper from connector J5. (See Figure 6-4.) Do not remove any of the control printed circuit board PROMs.

b. Refer to Tables 4-2 through 4-7 for detailed information for the free-running tests. For each test, set the signature analyzer controls and make signature analyzer connections as specified in the applicable table.

NOTE

For instruments containing PROMS with codes differing from those referred to in the various signature analysis tables, contact the Boonton Service Dept. for correct signatures.

c. After setting and connecting the signature analyzer, apply power to the instrument. Touch the signature analyzer probe to the specified measurement points and compare the signatures obtained with those specified in the table. An incorrect signature is evidence of malfunction.

d. If an incorrect signature is noted, try replacing the integrated circuit(s) most intimately associated with the point at which the incorrect signature was obtained. For example, an incorrect signature in the address field would point to integrated circuit IC3 on the control printed circuit board, but the problem could be caused by any other integrated circuit or component tied to that address line.

e. A signature of 0000 is obtained with the signature analyzer probe connected to common (ground). Some other items that will produce this signature are:

1. A node stuck at logic 0.

2. A node at the signature analyzer clock frequency.

f. A signature of 755U or 7A70 is obtained with the signature analyzer probe connected to +5 volts. Some other items that will produce the same signatures are:

1. A node stuck at logic 1.

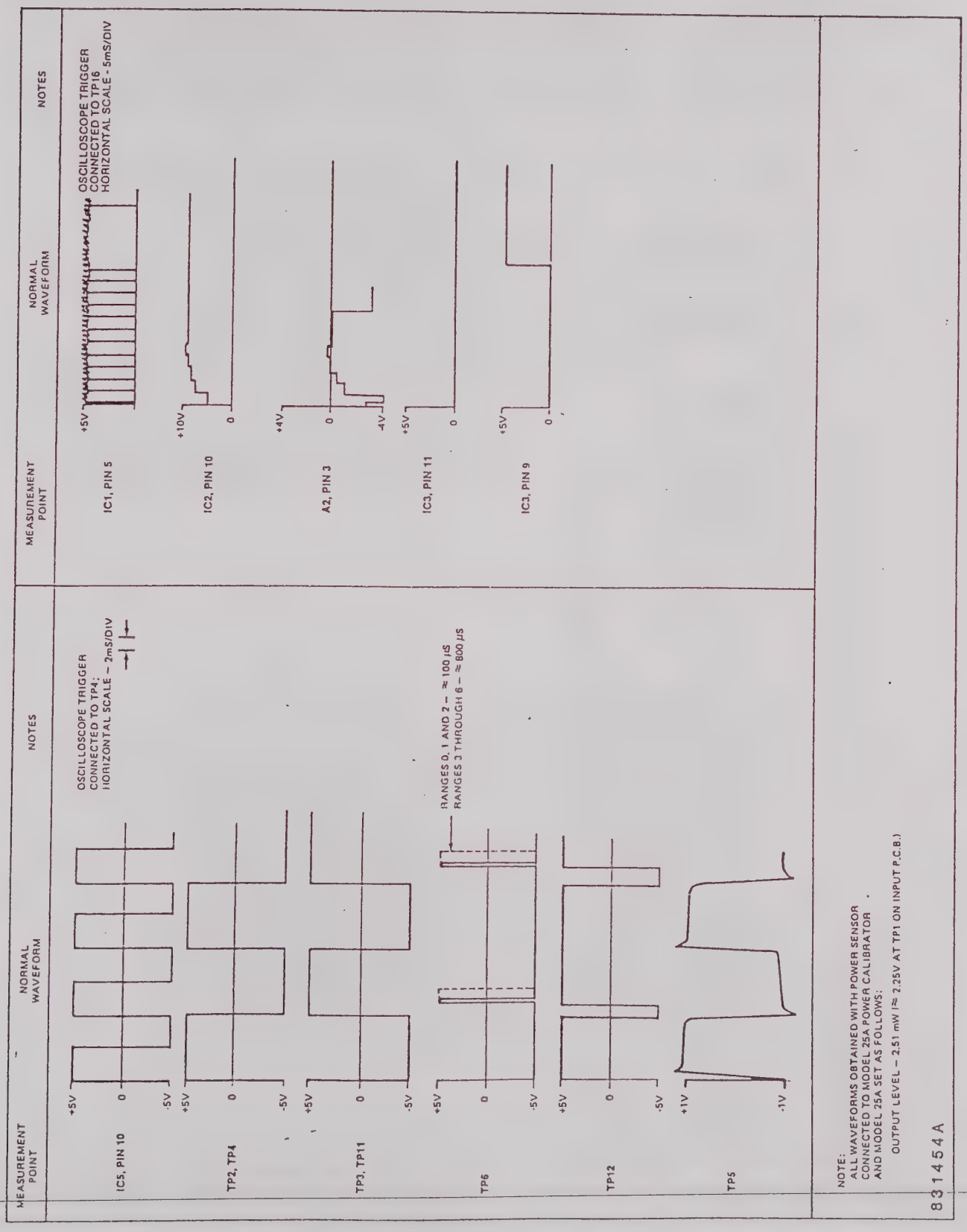
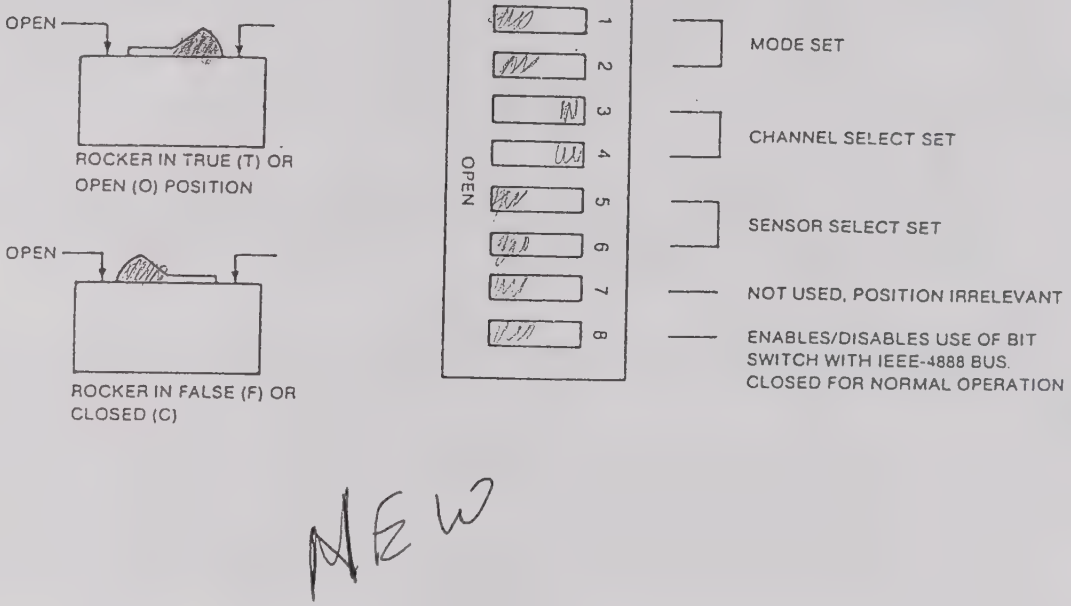


Figure 4-2 Input P.C. Board, Voltage and Waveform Data



NEW

SWITCH SETTING								COMMENT
8	7	6	5	4	3	2	1	
ALWAYS CLOSED	NOT USED							
						C	C	OPERATE MODE
						C	O	CALIBRATE MODE 1 (DC CAL.)
						O	C	CALIBRATE MODE 2 (AC CAL.)
				C	O			ONE CHANNEL OPERATION
				O	O			TWO CHANNEL OPERATION
		C	C					ONE SENSOR CAPABILITY
		C	O					TWO SENSOR CAPABILITY
		O	C					THREE SENSOR CAPABILITY
		O	O					FOUR SENSOR CAPABILITY

THE ACTUAL SWITCH SETTING WILL BE A COMBINATION OF THE ABOVE.

831455A

Figure 4-3 Control P.C. Board Bit Switch Settings

2. Any signal with a specific relationship to the clock signal. If the clock signal is signal RD from the microprocessor, signals IORQ, WR and RFSH are examples of signals that will produce these signatures.

g. Upon completion of the free-running checks, turn power off. Then, reinstall data bus connector P1 in socket J1 on the control pcb and reinstall jumper at connector J5.

NOTE

If programmed signature analysis tests are to be performed, leave jumper disconnected from connector J5.

TABLE 4-2. CONTROL BOARD ADDRESS FIELD TEST*

Function	Signature Analyzer Switch Setting	Connection Point	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	⌐	TP1				
STOP	⌊	TP1				
CLK	⌐	TP5	Any setting		Common	0000
	⌊				+5V	755U
				A0	IC3, pin 30	H335
	⌐			A1	IC3,pin 31	C113
	⌊			A2	IC3,pin 32	7050
				A3	IC3,pin 33	0772
				A4	IC3,pin 34	C4C3
				A5	IC3,pin 35	AA08
				A6	IC3,pin 36	7211
				A7	IC3,pin 37	A3C1
				A8	IC3,pin 38	7707
				A9	IC3,pin 39	577A
				A10	IC3,pin 40	HH86
				A11	IC3,pin 1	89F1
				A12	IC3,pin 2	AC99
				A13	IC3,pin 3	PCF3
				A14	IC3,pin 4	1180
				A15	IC3,pin 5	755U

*This test checks the output of the proper address field by CPU IC3; however, any item connected to an address line could be responsible for an incorrect signature on that line.
**O = open

TABLE 4-3. CONTROL BOARD MEMORY DECODING TEST*

Function	Signature Analyzer Switch Setting	Connection Point	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	⌐	TP1				
STOP	⌊	TP1				
CLK	⌐	TP5	Any setting		Common	0000
	⌊				+5V	755U
				$\overline{CSU}$	IC4,pin 1	FU4U
	⌐			$\overline{CS1}$	IC4,pin 2	A207
	⌊			$\overline{CS2}$	IC4,pin 3	H6A3
				$\overline{CS3}$	IC4,pin 4	HU34
				$\overline{CS4}$	IC4,pin 5	H24U

*This test checks decoding for selection of memory integrated circuits.
**O = open

TABLE 4-4. CONTROL BOARD I/O DECODING TEST*

Function	Signature Analyzer Switch Setting	Connection Point	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START		TP1				
STOP		TP1				
CLK		TP5				
			Any setting		Common	0000
					+5V	755U
				$\overline{CS0}$	IC14,pin 1	17UH
				$\overline{CS1}$	IC14,pin 2	7375
				$\overline{CS2}$	IC14,pin 3	253H
				$\overline{CS3}$	IC14,pin 4	8059
				$\overline{CS4}$	IC14,pin 5	PAOU

*This test checks decoding for selection of I/O integrated circuits.
**O = open

TABLE 4-5. CONTROL BOARD ROM 0 TEST*

Function	Signature Analyzer Switch Setting	Connection Point	Bit Switch 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START		TP7				
STOP		TP7				
CLK		TP5				
			Any setting		Common	0000
					+5V	826P
				D0	IC6,pin 9	P642
				D1	IC6,pin 10	C111
				D2	IC6,pin 11	5AC6
				D3	IC6,pin 13	P470
				D4	IC6,pin 14	4624
				D5	IC6,pin 15	2P41
				D6	IC6,pin 16	9456
				D7	IC6,pin 17	UF62

*This test checks the program content of ROM 0.

TABLE 4-6. CONTROL BOARD ROM 1 TEST*

Function	Signature Analyzer Switch Setting	Connection Point	Bit Switch 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START		TP19				
STOP		TP19				
CLK		TP5				
			Any setting		Common	0000
					+5V	826P
				D0	IC7,pin 9	P1AA
				D1	IC7,pin 10	P01P
				D2	IC7,pin 11	U865
				D3	IC7,pin 13	6A31
				D4	IC7,pin 14	A2CP
				D5	IC7,pin 15	HC35
				D6	IC7,pin 16	61U4
				D7	IC7,pin 17	H189

*This test checks the program content of ROM 1 (IC7).

TABLE 4-7. INTERFACE BOARD ROM 2 TEST

Function	Signature Analyzer Switch Setting	Signature Analyzer Connection Point	Bit Switch 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	]	TP18				
STOP	]	TP18				
CLK	]	TP5	Any setting		Common	0000
	]				+5V	826P
	]			D0	IC1, pin 9	826P
	]			D1	IC1, pin 10	19H6
	]			D2	IC1, pin 11	5H21
	]			D3	IC1, pin 13	C25F
	]			D4	IC1, pin 14	7C47
	]			D5	IC1, pin 15	3319
	]			D6	IC1, pin 16	8P3U
	]			D7	IC1, pin 17	3C4A

Signature analyzer connection points are on control board.

4-20. SIGNATURE ANALYSIS PROGRAMMED TEST PROCEDURES.

NOTE

Perform the free-running signature analysis tests before proceeding with programmed tests.

A Boonton Electronics diagnostic ROM kit, Part No. 96100301A is required for programmed signature analysis tests. This diagnostic ROM is included in Calibration Tape and Diagnostic ROM Kit part number 96200101A.

4-21. Use the following general procedure for each of the specified programmed signature analysis tests:

a. Turn off power to the instrument.

b. Remove ROMs IC6 and IC7 from their sockets on the control board, and remove ROM IC1 from its socket on the interface board (if option 9200B-01A is installed). (See Figures 6-4 and A-2.)

c. Install a Boonton Electronics diagnostic ROM in the socket from which ROM IC6 was removed, being careful to observe proper pin 1 orientation.

d. Check to see that connector P1 on the control board is connected to connector J1 and that connector P5 is connected to connector J5.

e. Turn on input power to the instrument.

f. Perform the test procedures specified in Tables 4-8 through 4-23. For each of the programmed signature analysis tests, make signature analyzer connections and switch settings as listed in the appropriate table. Then, set the bit switch on the control board as specified, connect the signature analyzer probe to the specified measurement points, and compare the signatures obtained on the signature analyzer with those listed in the table.

g. Note that in each signature analysis test the signature analyzer probe is first checked on common (ground) and then on +5 volts. If the specified signatures are not obtained for these checks, do not proceed further; subsequent signatures cannot possibly be correct. Recheck all signature analyzer connections and switch settings.

h. Both visual and signature analysis tests are provided for the display and keyboard of the instrument. Make the visual check first; it is fast and simple. If the visual check is satisfactory, the signature analysis test may be omitted.

i. If an incorrect signature is obtained at any point, replace the integrated circuit (or other active device) most intimately associated with the

4-21. (CONT.)

node at which the incorrect signature is obtained. All integrated circuits and transistors in the instrument are socket-mounted for easy removal and replacement. If the signature is still incorrect after all active devices have been checked, all passive devices connected to that node should be suspect.

NOTE

Make sure that power to the instrument is turned off before removing and installing the integrated circuits specified in the following step.

TABLE 4-8. CONTROL BOARD 4ABIO TEST*

Function	Signature Analyzer Switch Setting	Connection Point	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	⌐	TP6				
STOP	⌐	TP6				
CLK	⌐	TP5				
	⌐		C C C C C C C C		Common	0000
	⌐				+5V	0000
	⌐			PB0	J3, pin 1	0000
	⌐			PB1	J3, pin 2	0000
	⌐			PB2	J3, pin 3	0000
	⌐			PB3	J3, pin 4	0000
	⌐			PB4	J3, pin 5	0000
	⌐			PB5	J3, pin 6	0000
	⌐			PB6	J3, pin 7	0000
	⌐			PB7	J3, pin 8	0000
	⌐		O C C C C C C C	PB0	J3, pin 1	4F7C
	⌐		C O C C C C C C	PB1	J3, pin 2	4F7C
	⌐		C C O C C C C C	PB2	J3, pin 3	4F7C
	⌐		C C C O C C C C	PB3	J3, pin 4	4F7C
	⌐		C C C C O C C C	PB4	J3, pin 5	4F7C
	⌐		C C C C C O C C	PB5	J3, pin 6	4F7C
	⌐		C C C C C C O C	PB6	J3, pin 7	4F7C
	⌐		C C C C C C C O	PB7	J3, pin 8	4F7C

*This test checks operation of ports A and B of the control module I/O port; the function of the bit switch is checked collaterally.
**O = open; C = closed

TABLE 4-9. CONTROL BOARD 4CIO TEST*

Function	Signature Analyzer Switch Setting	Connection Point	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	⌐	TP6				
STOP	⌐	TP6				
CLK	⌐	TP5				
	⌐				Common	0000
	⌐				+5V	7C88
	⌐		O C C C C C C O	PC0	IC16,pin 14	5437
	⌐			PC1	IC16,pin 15	CCA9
	⌐			PC2	IC16,pin 16	1788
	⌐			PC3	IC16,pin 17	7C88

*This test checks the operation of part of port C of the control board I/O port.
**O = open; C = closed

TABLE 4-10. CONTROL BOARD 4DIO TEST*

Function	Signature Analyzer Switch Setting	Connection Point	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START		TP6				
STOP		TP6				
CLK		TP5				
					Common	0000
					+5V	58UA
			C O C C C C C O	PC4	IC16,pin 13	0000[1].
				PC4	IC16,pin 13	C35P[2].

*This test checks the operation of part of port C on the control board I/O port.
**O = open; C = closed
1. Line voltage = 120 volts
2. Line voltage = 90 volts

TABLE 4-11. DISPLAY VISUAL TEST

Bit Switch* 1 2 3 4 5 6 7 8	Instrument Display
O O C O O C C O	In succession: All zeros All ones through all nines All decimal points All left-most annunciators All left-most-1 annunciators All left-most-2 annunciators All right-most annunciators and - sign Repeat of above

NOTE: If this visual check produces satisfactory results, there is no need to perform the associated signature analysis check.
*O = open; C = closed

TABLE 4-12. CONTROL BOARD DISPLAY TEST* (ROM 950004)

Function	Signature Analyzer Switch Setting	Connection Point	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START		TP6				
STOP		TP6				
CLK		TP5				
					Common	0000
					+5V	F72F
			O O C O O C C O	D0	IC3, pin 14	94F8
				D1	IC3, pin 15	PH9U
				D2	IC3, pin 12	83FF
				D3	IC3, pin 8	4A1H
				D4	IC3, pin 7	H1P5
				D5	IC3, pin 9	F3A7
				D6	IC3, pin 10	P85F
				D7	IC3, pin 13	5536

*This test checks output of digital information to the display. The signature analysis gate in this test is quite lengthy (approximately 8 seconds); hold the signature analyzer probe on each test point for at least one complete window (approximately 20 seconds).
**O = open; C = closed

TABLE 4-13. CONTROL BOARD DISPLAY SCAN TEST*

Function	Signature Analyzer Switch Setting	Connection Point	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	┐	TP4				
STOP	┘	TP4				
CLK	┐	TP8				
	┘				Common	0000
					+5V	000U
	┐		O O C O O C C O	S0	IC18, pin 32	0000
				S1	IC18, pin 33	0005
				S2	IC18, pin 34	0003
	┘			S3	IC18, pin 35	000U

*This test checks the control board display I/O chip for output of encoded scan data.
**O = open; C = closed

TABLE 4-14. KEYBOARD VISUAL TEST*

Bit Switch** 1 2 3 4 5 6 7 8	Press Keyboard Key	Instrument Display
C C O C C C C O	MODE mV	0
	MODE dB	1
	RANGE AUTO	2
	LIMITS dB LO	3
	SELECT Z_o	4
	REF LEVEL dB	5
	MODE dBmV	8
	MODE dBV	9
	RANGE HOLD	10
	LIMITS dB HI	11
	SELECT CHNL	12
	CLR	13
	CHS	16
	5	17
	6	18
	7	19
	8	20
	9	21
	●	24
	0	25
	1	26
	2	27
	3	28
	4	29
	(SENS) PROBE	32
	ZERO	33

*This test is partly keyboard and partly control board because the I/O chip (IC18) for the display board resides on the control board.
**O = open; C = closed

TABLE 4-15. CONTROL BOARD RAM TEST*

Function	Signature Analyzer Switch Setting	Signature Analyzer Connection Point	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	⌐	TP6				
STOP	⌊	TP6				
CLK		TP5				
	⌐				Common	0000
	⌊				+5V	2915
			O C O C C C C O	PB0	J3, pin 1	5PPA
	⌐			PB1	J3, pin 2	77UU
				PB2	J3, pin 3	5PPA
				PB3	J3, pin 4	77UU
				PB4	J3, pin 5	5PPA
				PB5	J3, pin 6	77UU
				PB6	J3, pin 7	5PPA
	⌊			PB7	J3, pin 8	77UU

*This test writes bit patterns into each byte of the RAM, reads each byte and outputs it to the test socket at the rear of the control board where it is checked with the signature analyzer probe. While not completely exhaustive, this test will disclose most RAM failures.
**O = open; C = closed

TABLE 4-16. INPUT MODULE CHANNEL 1 OAIO TEST*

Function	Signature Analyzer Switch Setting	Signature Analyzer Connection Point***	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	⌐	TP6				
STOP	⌊	TP6				
CLK		TP5				
	⌐				Common	0000
	⌊				+5V	876P
			C O O C C C C O	PA0	IC1, pin 4	485P
	⌐			PA1	IC1, pin 3	1A33
				PA2	IC1, pin 2	F85P
				PA3	IC1, pin 1	5H7U
				PA4	IC1, pin 40	OFF1
				PA5	IC1, pin 39	F10C
				PA6	IC1, pin 38	9091
	⌊			PA7	IC1, pin 37	4P81

*This test checks the operation of I/O port A of the input module; correct signatures depend on proper functioning of both the control board and the input module.
**O = open; C = closed
***Signature analyzer connection points are on the control board; measurement points are on input module board.

TABLE 4-17. INPUT MODULE CHANNEL 1 OBIO TEST*

Function	Signature Analyzer Switch Setting	Connection Point***	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	┌	TP6				
STOP	└	TP6				
CLK		TP5				
	┌				Common	0000
	└				+5V	876P
			O O O C C C C O	PB0	IC1, pin 18	485P
	┌			PB1	IC1, pin 19	1A33
	└			PB2	IC1, pin 20	F85P
				PB3	IC1, pin 21	5H7U
				PB4	IC1, pin 22	OFF1
				PB5	IC1, pin 23	F10C
				PB6	IC1, pin 24	9091
				PB7	IC1, pin 25	4P81

*This test checks the operation I/O port B of the input module; correct signatures depend on proper functioning of both the control board and the input module.
**O = open; C = closed
***Signature analyzer connection points are on the control board; measurement points are on input module board.

TABLE 4-18. INPUT MODULE CHANNEL 1 OCIO TEST*

Function	Signature Analyzer Switch Setting	Connection Point***	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	┌	TP6				
STOP	└	TP6				
CLK		TP5				
	┌				Common	0000
	└				+5V	5064
			C C C O C C C O	PC0	IC1, pin 14	6UO1
	┌			PC1	IC1, pin 15	671U
	└			PC2	IC1, pin 16	CFH2
				PC3	IC1, pin 17	121H

*This test checks the operation of part of I/O port C on the input module; correct signatures depend on proper operation of both the input module and the control board.
**O = open; C = closed
***Signature analyzer connection points are on the control board; measurement points are on input module board.

TABLE 4-19. INPUT MODULE CHANNEL 1 ODIO TEST*

Function	Signature Analyzer Switch Setting	Connection Point***	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	┐	TP6				
STOP	┘	TP6				
CLK	┐	TP5				
	┘				Common	0000
					+5V 23HC[1]. or	5C43
			O C C O O C C C O	PB0	A5J3, pin	0000[1].
	┐			PB0	A5J3, pin	7H97[2].
	┘					

*This test checks part of I/O port C of the input module for channel 1.
**O = open; C = closed
***Signature analyzer connection points and measurement points are on control board.
1. Signature obtained with range calibrator connected to channel 1 input and range calibrator set to zero and R_S = 300k.
2. Signature obtained with range calibrator connected to channel 1 input and range calibrator set to range 5 and R_S = 300k.

TABLE 4-20. INPUT MODULE CHANNEL 2 1AIO TEST*

Function	Signature Analyzer Switch Setting	Connection Point***	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	┐	TP6				
STOP	┘	TP6				
CLK	┐	TP5				
	┘				Common	0000
					+5V	876P
			O O C O C C C O	PA0	IC1, pin 4	485P
	┐			PA1	IC1, pin 3	1A33
	┘			PA2	IC1, pin 2	F85P
				PA3	IC1, pin 1	5H7U
				PA4	IC1, pin 40	OFF1
				PA5	IC1, pin 39	F1OC
				PA6	IC1, pin 38	9091
				PA7	IC1, pin 37	4P81

*This test checks the operation of I/O port A on input module 2. Correct signatures depend on the proper operation of both the control board and input module 2.
**O = open; C = closed
***Signature analyzer connection points are on the control board; measurement points are on input module board.

TABLE 4-21. INPUT MODULE CHANNEL 2 1BIO TEST*

Function	Signature Analyzer Switch Setting	Connection Point***	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	⌐	TP6				
STOP	⌙	TP6				
CLK		TP5				
	⌐				Common	0000
	⌙				+5V	876P
			C C O O O C C C O	PB0	IC1, pin 18	485P
	⌐			PB1	IC1, pin 19	1A33
	⌙			PB2	IC1, pin 20	F85P
				PB3	IC1, pin 21	5H7U
				PB4	IC1, pin 22	OFF1
				PB5	IC1, pin 23	F1OC
				PB6	IC1, pin 24	9091
				PB7	IC1, pin 25	4P81

*This test checks the operation of I/O port B of input module 1. Correct signatures depend on proper operation of both the control board and input module 2.
**O = open; C = closed
***Signature analyzer connection points are on the control board; measurement points are on input module board.

TABLE 4-22. INPUT MODULE CHANNEL 2 1CIO TEST*

Function	Signature Analyzer Switch Setting	Connection Point***	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	⌐	TP6				
STOP	⌙	TP6				
CLK		TP5				
	⌐				Common	0000
	⌙				+5V	5064
			O C O O C C C O	PC0	IC1, pin 14	6UO1
	⌐			PC1	IC1, pin 15	671U
	⌙			PC2	IC1, pin 16	CFH2
				PC3	IC1, pin 17	121H

*This test checks the operation of I/O port C of input module 2. Correct signatures depend on proper operation of both the control board and input module 2.
**O = open; C = closed
***Signature analyzer connection points are on the control board; measurement points are on input module board.

TABLE 4-23. INPUT MODULE CHANNEL 2 1DIO TEST*

Function	Signature Analyzer Switch Setting	Connection Point***	Bit Switch** 1 2 3 4 5 6 7 8	Item	Measurement Point	Signature
START	⌐	TP6				
STOP	⌙	TP6				
CLK		TP5				
	⌐				Common	0000
	⌙				+5V P951[1] or	1088
			C O O O C C C O	PB0	A5J3, pin 1	0000[1]
	⌐			PB0	A5J3, pin 1	7H97[2]
	⌙					

*This test checks part of I/O port C of the channel 2 input module.
**O = open; C = closed
***Signature analyzer connection points and measurement points are on control board.
1. Signature obtained with range calibrator connected to channel 2 input, and range calibrator set to zero and R_S = 300k.
2. Signature obtained with range calibrator connected to channel 2 input, and range calibrator set to range 5 and R_S = 300k.

4-21. (CONT.)

j. At the completion of all programmed signature analysis tests, turn off power to the instrument, remove the Boonton Electronics diagnostic ROM from the control board, and install ROMs IC6 and IC7 in their sockets on the control board and ROM IC1 in its socket on the interface board, ensuring that proper pin 1 orientation is observed.

k. Restore bit switch (Figure 4-3) on the control board to the settings recorded at the start of signature analysis tests.

4-22. NON-VOLATILE RAM CIRCUIT TESTS.

4-23. Non-Volatile RAM Test. To test the non-volatile RAM, proceed as follows:

NOTE

Leave Boonton Electronics diagnostic ROM, part number 961003, installed on the control board as for the programmed signature analysis tests. Make sure that connector P5 on the control board is connected to connector J5.

a. With power applied to the instrument, set all eight segments of the bit switch on the control board to the open position.

b. Observe the instrument display. It should provide an error indication (cccc) initially.

c. Turn input power off, then back on. If the non-volatile RAM is operating properly, the instrument display will show 1111.

d. Repeat step c several times. The instrument display should always show 1111, not the error indication.

e. Upon completion of this test, turn off input power to the instrument, remove the diagnostic ROM from the control board, and install integrated circuits IC6 and IC7 in their sockets on the control board and integrated circuit IC1 on the interface board (if option 9200B-01A is installed), making certain that proper pin 1 orientation is observed.

4-24. Non-Volatile RAM Cell Test. To test the non-volatile RAM cell, proceed as follows:

CAUTION

The following test procedure must be adhered to strictly; otherwise, instrument data stored in the non-volatile memory will be lost. Do not attempt to take measurements other than those specified. Take all necessary precautions to ensure that no terminals are shorted to another terminal or to common (ground).

NOTE

The load imposed on the cell by the non-volatile RAM is 5.25 µA or less. With this load, the cell has a rated life of at least 100,000 hours, which is greater than 10 years.

a. Remove the screws that secure the non-volatile RAM cover and remove the cover to gain access to the cell terminals.

b. Connect a digital multimeter between the cell positive terminal and ground, ensuring that the cell is not shorted to ground at any time.

c. Observe the digital multimeter indication; it should be approximately 3 volts with input power to the instrument turned off. If the indications is much lower than 3 volts, replace the cell in accordance with the procedures in paragraph 4-25.

4-25. Non-volatile RAM Cell Replacement. (See Figure 4-4.) The replacement time for the cell is expected to be 10 years from the time of manufacture. This is the shelf life of the cell. If the cell replacement is needed, restoration of all instrument calibration data will be required. To replace a defective cell, proceed as follows:

4-25. (CONT.)

CAUTION

Use care to avoid shorting the leads of the replacement cell. Shorting will cause discharge of the cell and result in reduced cell lifetime.

a. Remove the control printed circuit board from the instrument.

b. Remove the insulating shields from the non-volatile RAM section.

c. Disconnect the positive lead of the defective cell by cutting the lead.

d. Unsolder the defective cell using a low-wattage soldering iron and remove excess solder from the mounting holes.

e. Install the replacement cell, observing cell polarity.

f. Solder the negative terminal of the cell first. Then, as quickly as possible, solder the positive terminal.

g. Check the non-volatile RAM current by measuring the voltage across resistor R6. The voltage should be less than 525 microvolts.

h. Measure the voltage at pin 24 of integrated circuit IC8. This voltage should be approximately 3 volts.

i. Reassemble the shields on the control printed circuit board. Install the control printed circuit board in the instrument.

4-26. NON-VOLATILE MEMORY DATA.

NOTE

Factory-entered data is shown on a hard copy stored under the ~~right side panel~~ TOP COVER of the instrument.

4-27. General. Data have been entered in to the non-volatile memory of the instrument at the factory for the instrument and for the probe(s) ordered with the instrument. Field entry of data is not required unless stored data are destroyed or their accuracy becomes suspect, or if another probe is to be used with the instrument. A description of the types of data stored in non-volatile memory is provided in the following paragraphs.

4-28. Instrument Gain Data. The front end of the instrument input module is a balanced-input DC amplifier with seven decade ranges with nominal full-scale inputs of 20 microvolts to 20 volts. The output is an unbalanced DC with a 2.5 volt full-scale value for each range; the DC is converted into a proportional digital value. One manual gain adjustment, potentiometer R44, adjusts the gain of all ranges by the same amount; this adjustment is factory set during instrument calibration. Individual range adjustments are accomplished through software correction or adjustment, which is also determined during instrument calibration. The software corrections are stored in the instrument non-volatile memory. A gain factor associated with the recorder DC output is also stored in memory.

4-29. Probe Data. Low-frequency gain corrections are stored in the instrument non-volatile memory for each probe that is calibrated with the instrument. Low-frequency gain corrections are of two types: a gain factor for each range, and a gain correction for each range. Any probe procured independently of the instrument must have its low-frequency gain data entered and stored in the non-volatile memory prior to the use of that probe.

4-30. Instrument Operation-Related Data. Instrument gain data and probe data are fixed for a given instrument and probe(s). The instrument non-volatile memory stores these together with measurement parameters most recently selected by the operator. Entry of measurement parameters is described in paragraph 2-15. The non-volatile memory retains the operator-selected parameters until they are changed, maintaining current values through power off/power on.

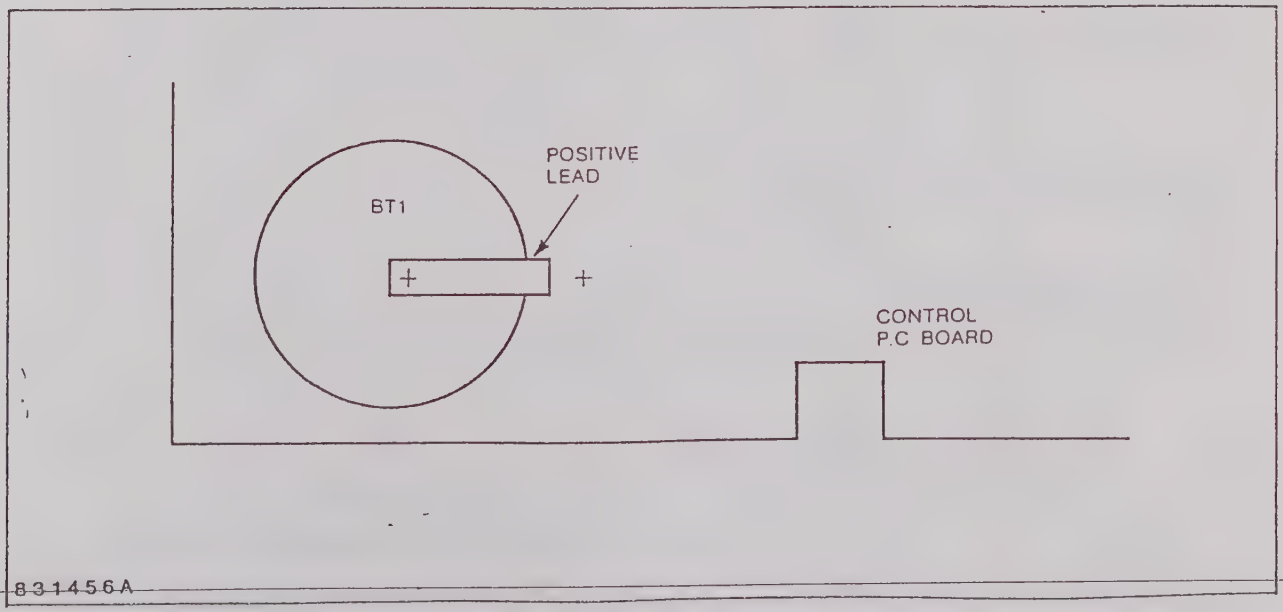


Figure 4-4 Non-Volatile RAM Cell Test and Connection Points

4-31. RECALL AND ENTRY OF INSTRUMENT GAIN DATA.

4-32. The following subparagraphs provide instructions for recall and entry of instrument gain data.

a. Gain Factor Recall. To recall the instrument gain factors stored for each channel of the instrument, proceed as follows:

1. Set the control board bit switch to mode 1. (See Figure 4-3.)

2. Using the instrument keyboard, select the channel for which gain factors are to be recalled. For example: to select channel 1, press the 1 and SELECT CHNL keys.

3. Press the MODE dBw key. The instrument display will show approximately 1185; this is the recorder output gain factor.

4. Using the keyboard keys, select the range to be checked. For example: to select range 0, press the 0 and MODE dBV keys.

5. Press the REF LEVEL dB key. The instrument display will indicate the gain factor stored for the selected channel and range; this value should be in the vicinity of 1000.

6. Repeat steps 3 and 5 for each of the remaining ranges to be checked.

7. After all desired gain factors have been recalled, reset the control board bit switch (Figure 4-3) to mode 0.

b. Instrument Gain Factor Entry. To correct or reintroduce an instrument gain factor, proceed as follows:

1. Set the control board bit switch (Figure 4-3) to mode 1.

2. Using the keyboard keys, select the channel for which gain factor correction or reintroduction is required. For example: to select channel 2, press the 2 and SELECT CHNL keys.

3. Using the keyboard keys, select the range for which the gain factor is to be corrected or reintroduced. For example: to select range 2, press the 2 and MODE dBV keys.

4. Using the keyboard keys, enter the desired gain factor as a REF LEVEL dB value. For example: to enter a gain factor of 1023, press the 1, 0, 2 and 3 numeric keys, then press the REF LEVEL dB key.

5. Press the REF LEVEL dB key a second time. The instrument display will indicate the entered gain factor value.

6. Repeat steps 3 through 5 for each of the remaining ranges for which entry of a gain factor is desired.

7. Upon completion of gain factor entries, reset the control board bit switch (Figure 4-3) to mode 0.

4-33. RECALL AND ENTRY OF PROBE DATA.

a. Entry of Probe (SENS) Serial Number. To enter the probe serial number proceed as follows:

1. Set the control board bit switch to MODE 2 (Figure 4-3).

2. Select the probe (SENS) number (1 through 8) with N, PROBE keys.

3. Enter the probe (SENS) serial number with digit keys N, N, N, N and depress the AVERAGE AUTO key.

4. Set the control board bit switch to MODE 0 (OPERATE MODE).

The probe (SENS) serial number can be recalled by pressing the •, PROBE keys.

4-34. Gain factor and gain correction data are stored in the instrument non-volatile memory for each probe supplied with the instrument. To recall or enter probe data, use the following procedures, as applicable.

4-34. (CONT.)

a. Probe Data Recall. To recall stored probe data, proceed as follows:

1. Set the control board bit switch (Figure 4-3) to mode 0.

2. Using the keyboard keys, select the probe for which stored probe data is to be recalled. For example: if stored data for the 1 probe is to be recalled, press the 1 and SELECT PROBE keys.

3. Set the control board bit switch to mode 2.

4. Using the keyboard keys, select the range for which the probe gain factor is desired. For example: if the gain factor for range 0 is to be recalled, press the 0 and MODE dBV keys.

5. Press the REF LEVEL dB key. The instrument display will show the stored gain factor (approximately 5000) for the selected range.

6. Press the MODE dBw key. The instrument display will show a down-scale correction (generally 0 on range 0).

7. Repeat steps 4 through 6 for each of the other ranges for which the stored gain factor is to be recalled.

8. Set the control board bit switch (Figure 4-3) to mode 0.

b. Entry of Probe Gain Factor and Gain Correction. Probe (sensor) data cannot be entered for a probe (SENS) number which is not accommodated by the control board bit switch setting for N PROBE (SENS) capability. (See Figure 4-3.) If this is attempted, the instrument will display an error message. If the instrument was originally supplied with 2 probes and it is desired to enter data (or calibrate) for a third, bit switches 5, 6 and 7 will have to be set for 3 probe capability with the new data entered for probe 3. Figure 4-3 gives the bit switch settings for 1 through 8 probe (sensor) capability. Proceed as follows:

1. Using the keyboard keys, select the probe for which the data is to be entered. For example: if the data to be entered applies to probe 1, press the 1 and PROBE (SENS), SELECT PROBE keys.

2. Set the control board bit switch (Figure 4-3) to mode 2.

3. Using the keyboard keys, select the range for which a probe gain factor entry is to be made. For example: if the probe gain factor for range 0 is to be entered, press the 0 and MODE dBV keys.

4. Using the numerical keys, enter the probe gain factor for the selected range; then, press the REF LEVEL dB key. For confirmation of correct probe gain factor entry, press the REF LEVEL dB key a second time; the stored probe gain factor for the selected range will appear on the instrument display.

5. Repeat steps 5 and 6 for each of the other instrument ranges for which probe gain factors are to be entered.

6. Select the instrument range for which the probe gain correction is to be entered. For example: if the probe gain correction for range 2 is to be entered, press the 2 and MODE dBV keys.

7. Using the numerical keys, enter the probe gain correction for the selected range, then press the MODE X100 key. For confirmation of correct probe gain correction entry, press the MODE X100 key a second time; the stored gain correction for the selected range will appear on the instrument display.

8. Repeat steps 8 and 9 for each of the other instrument ranges for which probe gain corrections are to be entered.

9. Upon completion of data entry, reset the control board bit switch (Figure 4-3) to mode 0.

4-35. INSTRUMENT ADJUSTMENT AND CALIBRATION.

4-36. GENERAL. Test equipment required for instrument adjustment and calibration is as follows:

4-36. (CONT.)

a. Digital voltmeter (3½ digits).

b. RF Millivoltmeter Calibrator, Boonton Electronics Model 26A.

c. Range Calibrator, Boonton Electronics Model 2500.

NOTE

In the following adjustment procedures, all voltage measurements are referred to common unless otherwise specified.

4-37. Power Supply Adjustments. With all power connectors in place, the instrument controls set for line operation and the correct line voltage applied, make power supply adjustments as follows:

a. Connect the digital voltmeter between common and test point TP3. The voltage indication should be 5.20 ±0.002 volts. Adjust potentiometer R5 on the power supply board as required to obtain the specified indication.

b. Connect the digital voltmeter between test points TP2 and TP4. The voltage indication should be 150 ±10 millivolts. (The polarity of the reading will depend on how the test probes are connected.) Adjust potentiometer R11 on the power supply board as required to obtain the specified indication.

c. Connect the digital voltmeter between test point TP1 and common. The voltage indication should be +15 ±0.6 volts.

d. Connect the digital voltmeter between test point TP5 and common. The voltage indication should be -15 ±0.6 volts.

e. Connect the digital voltmeter between test point TP6 and common. The voltage indication should be -5 ±0.2 volts.

4-38. Input Module Calibration and Adjustments. The input modules are capable of operating with either:

Model 952001 High Impedance Probe

Model 952009 50 Ω Probe

Add 952016

In the adjustments which follow, the Model 2500 source resistance should be set as follows:

PROBE	SOURCE RESISTANCE
Model 952001	300 k
Model 952009	500 k
Model 952016	300 K

a. Connect 2500 to Channel port on 9200B. If there are 2 inputs, input module 1 is mounted under input module 2; input module 2 must be removed to calibrate input module 1. Adjust input module 1 first. Set control board bit switch (Figure 4-3) to Calibrate Mode 1.

b. Depress 2500 ZERO and set to RANGE 0. On 9200B, depress 1 CHNL, 0 dBV, mV.

c. Set DMM to DCV and connect TP9 on input module.

d. Short TP7 and TP8 on input module to ground. Adjust R45 for 0 VDC ±15mV DC.

e. Remove ground from TP8 and adjust R36 for 0 VDC ±15mV DC.

NOTE

If R24 is omitted remove ground from TP7 and go to step g.

f. Remove ground from TP7 and connect DMM to TP5. Adjust R24 for 0 VDC ±0.1 VDC.

4-38. (CONT.)

g. Connect DMM to TP9. Adjust R4 and R5 equally for a reading between 0 VDC and -0.2 VDC, but as close to 0 VDC as possible. Remove DMM.

h. On 9200B, depress ZERO. After zero cycle is completed set 2500 to range 5 and release ZERO. Depress 5 dBV and adjust R1 for 184.3 on 9200B display (See note below). Set 2500 to RANGE 2, depress 2 dBV and record display reading. Set 2500 to RANGE 1 and adjust R11 for one tenth of reading recorded in RANGE 2.

EXAMPLE: RANGE 2 read 184.3, set RANGE 1 for 018.4

NOTE

If there is not enough range on R1 or R11, center R1 and R11 with 2500 set to RANGE 5, and adjust R44 for 184.3 on display. Set 2500 to RANGE 1 and adjust R11 as indicated in step h. There is some interaction between R1 and R11 so recheck adjustments.

For second input module calibration repeat steps a thru h at CHNL 2. Step b should be 2 CHNL. Number 2 input module is mounted on top of number 1 input module.

i. Set control board bit switch (Figure 4-3) to OPERATE MODE.

4-39. **DC Calibration.** Make DC calibration adjustments as follows:

a. Connect 2500 to Probe port to be calibrated. Set control board bit switch (Figure 4-3) to OPERATE MODE. Depress 2500 ZERO and set to RANGE 0, 300 k (500 k for 952009 sensor). On 9200B, depress 1 CHNL (2 CHNL for calibration), 0, REF LEVEL dB, ZERO. After zero cycle is complete, set control board bit switch to CALIBRATE MODE 1. Release Model 2500 ZERO key.

b. Set 2500 to RANGE 0, depress 0, dBV, allow instrument time to settle, 18.43, mode dBmV, AVERAGE SELECT, REF LEVEL dB.

c. Set 2500 to RANGE 1, depress 1, dBV, settle, AVERAGE SELECT, REF LEVEL dB.

d. Set 2500 to RANGE 2, depress 2, dBV, settle, AVERAGE SELECT, REF LEVEL dB.

e. Set 2500 to RANGE 3, depress 3, dBV, settle, AVERAGE SELECT, REF LEVEL dB.

f. Set 2500 to RANGE 4, depress 4, dBV, settle, AVERAGE SELECT, REF LEVEL dB.

g. Set 2500 to RANGE 5, depress 5, dBV, settle, AVERAGE SELECT, REF LEVEL dB.

h. Set 2500 to RANGE 6B, depress 6, dBV, settle, AVERAGE SELECT, REF LEVEL dB.

i. Remove 2500. Set control board bit switch to OPERATE MODE.

4-40. **AC Calibration.** The AC calibration consists of: channel selection, probe selection, shaping table selection and three adjustments for each range. To perform the AC calibration, proceed as follows:

a. Connect the probe to the Model 26A Calibrator and allow both the calibrator and the Model 9200B to warm up for at least one-half hour. Depress the ZERO button on the Model 26A. On the Model 9200B, select Channel 1 or Channel 2, as required and probe number.

NOTE

When calibrating the Model 952009 sensor, the internal 50Ω shunt on the output of the Model 26A Calibrator must first be disconnected.

b. Select the proper shaping table by setting the bit switch (Figure 4-3) to CALIBRATE MODE 2 and pressing 0, SELECT Z_O, for Model 952001 High

4-40. (CONT.) or 952016 LOW FREQUENCY PROBE

Impedance Probe; or 1, SELECT Z_O, for Model 952009 50Ω Voltage Probe. Leave the control board bit switch in CALIBRATE MODE 2 for subsequent operations.

NOTE

The result of any adjustment or correction can be determined at any time by returning the control board bit switch to the OPERATE MODE and pressing MODE mV keys. Return to CALIBRATE MODE 2 if further calibration is to be done.

c. Clear previous midscale and downscale corrections by pressing:

0 MODE dBV, 0, MODE dBw, 0, MODE X100 (CLEARS RANGE 0)

1 MODE dBV, 0, MODE dBw, 0, MODE X100 (CLEARS RANGE 1)

2 MODE dBV, 0, MODE dBw, 0, MODE X100 (CLEARS RANGE 2)

3 MODE dBV, 0, MODE dBw, 0, MODE X100 (CLEARS RANGE 3)

4 MODE dBV, 0, MODE dBw, 0, MODE X100 (CLEARS RANGE 4)

5 MODE dBV, 0, MODE dBw, 0, MODE X100 (CLEARS RANGE 5)

6 MODE dBV, 0, MODE dBw, 0, MODE X100 (CLEARS RANGE 6)

NOTE

Pressing N and then MODE dBV selects range N. Pressing 0 and then MODE dBw clears midscale correction. Pressing 0 and then MODE X100 clears downscale correction.

d. Zero the Model 9200B by pressing 0, MODE dBV, MODE mV, ZERO. Wait for the completion of the zeroing process (digit display blanks, then returns). If the zero indication is not less than ±50 counts, repeat zero until this is obtained. In step e which follows, the instrument should be re-zeroed, if necessary, just prior to adjusting each of the three lowest ranges.

e. To adjust the full scale gain, set the Models 26A and 9200B as follows:

MODEL 26A	MODEL 9200 PRESS		MODEL 9200B DISPLAY
0.7 mV	0,MODE dBV,	7,.,0,0,MODE dBmV,(WAIT)[2] AVERAGE SEL, REF LEVEL dB	≈5000[3]
2.1 mV	1,MODE dBV,	2,1,.,0,0,MODE dBmV,(WAIT) AVERAGE SEL, REF LEVEL dB	≈5000
7 mV	2,MODE dBV,	7,0,.,0,0,MODE dBmV,(WAIT) AVERAGE SEL, REF LEVEL dB	≈5000
24 mV	3,MODE dBV,	2,4,.,0,0,MODE dBmV,(WAIT) AVERAGE SEL, REF LEVEL dB	≈5000
100 mV	4,MODE dBV,	9,9,.,9,9,MODE dBmV,(WAIT) AVERAGE SEL, REF LEVEL dB	≈5000
700 mV	5,MODE dBV,	7,0,.,0,0,MODE dBmV,(WAIT) AVERAGE SEL, REF LEVEL dB	≈5000
3000 mV	6,MODE dBV,	3,0,.,0,0,MODE dBmV,(WAIT) AVERAGE SEL, REF LEVEL dB	≈5000

[2]Allow sufficient time for display to settle.
[3]An indication between 4500 and 5500 is probably normal.

After each range adjustment above, the quality of the adjustment may be examined by setting the bit switch on the control board to OPERATE MODE and pressing the MODE mV and RANGE AUTO keys; the indication should agree with the input (Model 26A setting) within several counts. If closer agreement is desired, either repeat the procedure for that range or manually adjust the gain factor for that range by pressing:

X,X,X,X, REF LEVEL dB

EXAMPLE

After the normal routine, the indication for the 100 mV range is 99.8 (0.2% low). Set the bit switch to CALIBRATE MODE 2 and recall the gain factor by pressing 4, MODE dBV, REF LEVEL dB.

A gain factor of 5040 is displayed. The desired change is +0.2%. Increase the gain factor by 0.2% (≈10) to 5050 and enter by pressing:

5,0,1,0, REF LEVEL dB

Recheck in the OPERATE MODE.

f. Midscale Correction. In step c all the midscale corrections were set to 0 (no correction), and for the majority of probes this is quite satisfactory If it is found that a midscale correction is desirable it may be introduced as follows:

MODEL 26A	MODEL 9200B PRESS	
1.5 mV	1, MODE dBV,	X,X,X, MODE dBw
5 mV	2, MODE dBV,	X,X,X, MODE dBw
15 mV	3, MODE dBV,	X,X,X, MODE dBw
60 mV	4, MODE dBV,	X,X,X, MODE dBw
300 mV	5, MODE dBV,	X,X,X, MODE dBw
1500 mV	6, MODE dBV,	X,X,X, MODE dBw

The midscale correction will also effect the full scale indication, but to a lesser degree. Full scale may be readjusted as was outlined in step e. This will, however, effect the midscale correction again. Moreover, there is not a one-to-one relationship between the counts entered for the midscale correction and the correction which results.

If one does not wish to readjust full scale, enter the number of counts that midscale is in error; this will result in under-correction for midscale but will disturb full scale the least.

If the greatest accuracy is desired and full scale will be readjusted, enter three times the counts by which midscale is in error.

EXAMPLE

The 3000 mV range having just been calibrated is reading 3000 mV. However, 1500 (midscale) is reading 1497; the error here is three counts. Correct as follows:

CORRECTION (AUTO)	AFTER CORRECTION MID	AFTER CORRECTION FULL	COMMENT
0	1497	3000	No midscale correction
3	1498	3001	No full scale adjustment
9(3 x 3)	1501	3004	No full scale adjustment
9(3 x 3)	1499	3000	Full scale re-adjusted

g. Downscale Correction. To correct downscale indications, proceed as follows:

MODEL 26A	MODEL 9200B PRESS	
0.21 mV	0, MODE dBV	X,X,X, MODE X100
1.0 mV	1, MODE dBV	X,X,X, MODE X100
2.4 mV	2, MODE dBV	X,X,X, MODE X100
10 mV	3, MODE dBV	X,X,X, MODE X100
30 mV	4, MODE dBV	X,X,X, MODE X100
210 mV	5, MODE dBV	X,X,X, MODE X100
1000 mV	6, MODE dBV	X,X,X, MODE X100

4-40. (CONT.)

Again, there is not a one-to-one relationship between the value entered and the correction which results. For these corrections, enter a value which is twice the desired correction. Downscale corrections have no effect on full scale indications. The reverse is not true however; therefore, full scale adjustment (and midscale corrections, if used) should be made prior to downscale corrections.

h. Calibration Check. Finally, check the results of calibration at the following levels:

SCALE	RANGE	INPUT
Full	6	3000 mV
Mid	6	1500 mV
Down	6	1000 mV
Full	5	700 mV
Mid	5	300 mV
Down	5	210 mV
Full	4	100 mV
Mid	4	60 mV
Down	4	30 mV
Full	3	24 mV
Mid	3	15 mV
Down	3	10 mV
Full	2	7 mV
Mid	2	5 mV
Down	2	2.4 mV
Full	1	2.1 mV
Mid	1	1.5 mV
Down	1	1.0 mV
Full	0	0.7 mV
Mid	0	0.5 mV
Down	0	0.21 mV

All indications should fall well within the uncertainties specified in the Performance Specifications of Section I, Table 1-3.

NOTE

Because of range overlap it is possible in some instances to get an indication on two adjacent ranges for the same input level. Generally the indication near full scale (as opposed to downscale on the next higher range) will be the more accurate.

4-41. DC Recorder Calibration. Make DC Recorder adjustments as follows:

a. Set control board bit switch to OPERATE MODE. If the instrument is equipped with channel 2 (option 9200B-03), temporarily remove option to gain access to R55 on channel 1 (accessible through hole in channel 1 cover).

b. Connect DMM to recorder BNC connector on rear panel. Connect RF Probe to channel to be calibrated and to the 26A. Set 26A to ZERO. On 9200B, depress 1 channel (2 channel if 2nd channel is to be calibrated), N, PROBE, 0, REF LEVEL dB, AUTO, mV, ZERO.

c. After ZERO cycle is completed, set 26A to 1000 mV. DMM should read 10 V for display of 100 mV ±0.1%. If not, set control board bit switch to CALIBRATE MODE 1. Depress AUTO. Display should read approximately 1170. Perform the following: [Display indication ÷ (100 x DMM indication)] x the number located in AUTO.

EXAMPLE: Display reads 1000. DMM reads 9.96. AUTO reads 1163.[1000 ÷ (100 x 9.96)] x 1163 = 1168.

4-41. (CONT.)

d. With control board bit switch in CALIBRATE MODE 1, depress the number calculated above (i.e., 1168) followed by AUTO. Set control board bit switch to OPERATE MODE. Depress HOLD. Check DMM for accuracy indicated above. Set 26A for 300 mV. Adjust R55 for DMM to read 3 V for 300 mV display.

EXAMPLE: Display reads 0299. DMM reads 2.97. Adjust DMM to read 2.99. Full scale and down scale adjustment interact so re-check full scale and down scale until accuracy is obtained. Set control board bit switch to OPERATE MODE when complete.

e. This completes all 9200B calibration adjustments.

4-42. PROBE SWR AND FREQUENCY RESPONSE TESTS.

4-43. General. The RF probe and probe accessories used with the instrument can be checked for SWR and frequency response using the procedures in the following paragraphs. If an RF probe should exhibit out-of-tolerance performance in these tests, do not attempt to repair the probe; return it to the factory for repair or adjustment.

4-44. SWR Test. Proceed as follows:

a. Connect a slotted line to a signal source of the desired frequency range, and terminate the slotted line with the accessory device to be tested (i.e., Model 952003 50Ω N Tee Adapter and Model 952014 50Ω N Termination, or Model 952002 50Ω BNC Adapter).

b. Connect the RF probe and RF voltmeter to the accessory being tested. The RF probe supplies a perturbation for which the accessory has been designed and the RF voltmeter permits the test level to be set to the desired value.

c. Move the carriage of the slotted line to a point of minimum voltage, then to a point of maximum voltage. Record the minimum and maximum voltage values.

d. The SWR is the ratio of the maximum and minimum voltages.

e. Repeat the SWR measurement at other frequencies and levels, as required.

4-45. Frequency Response Tests. The most accurate method of measuring the frequency response of the RF probe is through use of micropotentiometers, electrothermic AC-DC transfer instruments and attenuator-thermoelement voltmeters. Users who have such instruments available will be familiar with their use. Another method, with an accuracy compatible with the accuracy of the instrument, uses a point-by-point frequency scan in conjunction with a power splitter and calibrated RF microwattmeter. To use this method, proceed as follows:

a. Connect the equipment as shown in Figure 4-5.

b. Set the frequency of the signal generator to 10 MHz, and adjust the signal generator output to the desired test level. If the response is to be measured at only one level, a test voltage of 100 millivolts is recommended.

c. Disable the output of the signal generator momentarily and zero the RF microwattmeter.

d. Restore the signal generator output level and note the reading on the RF microwattmeter. Record the frequency of the signal generator and the indication on the RF millivoltmeter.

e. Change the signal generator output frequency, in whatever increments are desired, through the range of 10 to 1200 MHz, holding the reference reading on the RF microwattmeter constant. Record the frequency and RF millivoltmeter indication for each test frequency.

f. Reverse the output ports of the power splitter and repeat steps b through e.

g. Average the two readings obtained for each test frequency to obtain the correct RF voltmeter reading.

RF PROBE FREQ. RESP. TEST SETUP

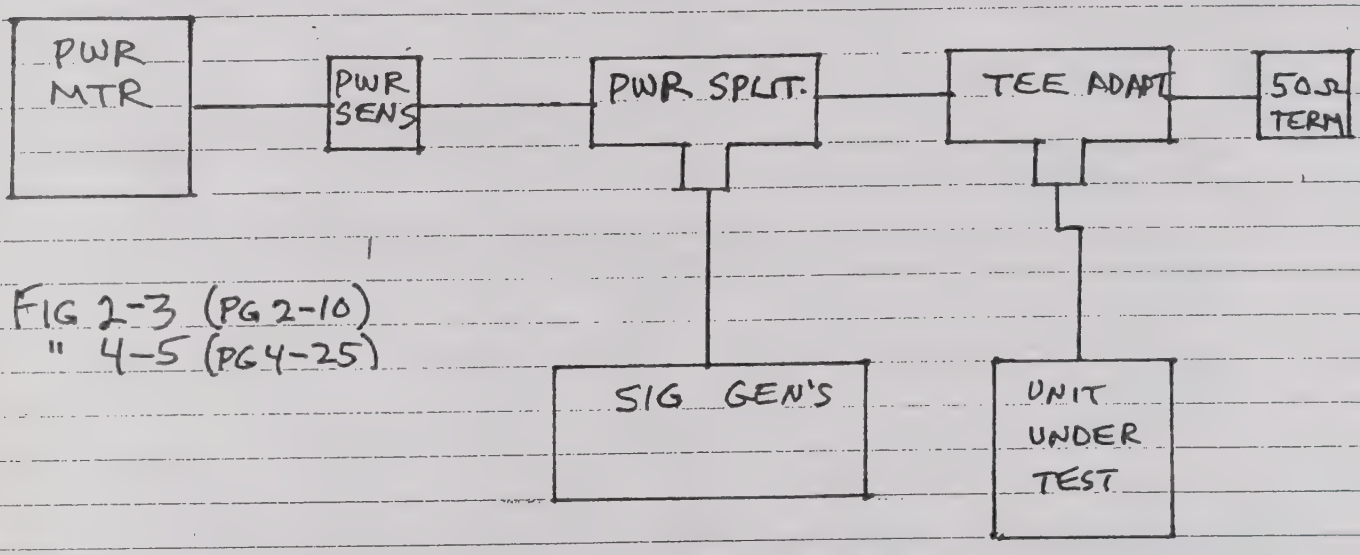


FIG 2-3 (PG 2-10)
" 4-5 (PG 4-25)

1. H.P. SIG. GEN. 8640B (10MHz — 1000MHz)
" " 8620C w/86222C P.I. (1200MHz)
2. H.P. PWR METER 435A
SENS. 8482A
3. H.P. 50Ω TERM 908A
4. WEINSCHEL PWR SPLITTER 1870A
5. BEC 'N' TEE ADAPTER 952003 OR 91-14A
6. BEC 9200A/B (U.U.T.)

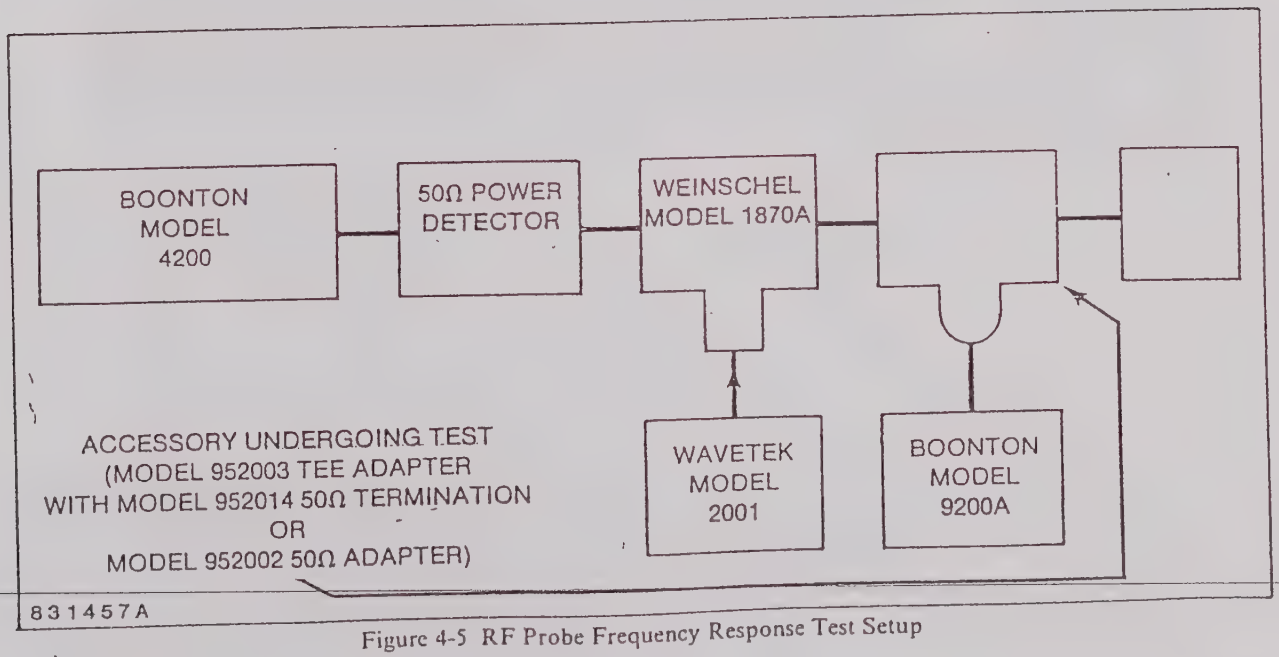


Figure 4-5 RF Probe Frequency Response Test Setup

4-45. (CONT.)

h. Further refinements can be made by filtering the output of the signal generator and measuring the complex reflection coefficients of the RF microwattmeter, accessory under test and all ports of the power splitter. The usual corrections can then be made. These procedures are not usually necessary and should be performed only if the additional accuracy is warranted.

4-46. **Alternate Frequency Response and SWR Test Procedure.** An alternate method of measuring both the frequency response and SWR (in terms of the reflection coefficient), with somewhat reduced accuracy, uses a sweep generator, SWR bridge, external leveling of the generator, power splitter and sensitive oscilloscope. The procedure is as follows:

a. Connect the equipment as shown in Figure 4-6.

b. Disconnect the RF probe cable from the oscilloscope and connect it temporarily to an RF millivoltmeter. Adjust the output control of the sweep generator to provide an RF millivoltmeter indication of 100 millivolts at a fixed frequency of 100 MHz. Then, restore the original RF probe connection to the oscilloscope.

c. Calibrate one of the vertical input amplifiers of the oscilloscope for a sensitivity of 100 microvolts per division. Calibrate the other vertical input amplifier so that a change from 100 millivolts to 90 millivolts applied to the input of the RF probe under test will produce a vertical deflection of 1 division. This can be done easily with a Boonton Model 26A RF Millivoltmeter Calibrator; connect the RF probe temporarily to the output of the RF millivoltmeter calibrator, adjust the output of the RF millivoltmeter calibrator to 100 millivolts and 90 millivolts alternately and adjust the sensitivity of the second vertical amplifier for a deflection of 1 division.

d. The SWR channel may be zeroed with a 50Ω termination (SWR<1.02) before connecting the mismatch termination. Substitute the standard 1.2:1 mismatch termination for the accessory under test and calibrate the graticule of the oscilloscope for the SWR of 1.2. Reconnect the accessory and probe.

e. Adjust the limits on the three bands of the sweep generator for coverage from 10 to 1200 MHz. Study the traces of both the frequency-response and SWR (return loss).

f. Reverse the output ports of the power splitter and repeat steps d and e.

g. Note that the permissible error for the frequency response trace expands with frequency. For the most meaningful results, mark the graticule with a grease pencil to show the maximum permissible errors for the various frequency bands, as determined with a calibrated signal of 1 MHz, and at levels above and below the selected test level. Note also that the recovered DC from the RF probe, which is applied to the second vertical input amplifier, will vary as the square of the RF input level for test levels of 30 millivolts or less. Above 30 millivolts, RF to DC conversion gradually changes from square law to linear and approaches a peak-to-peak rectifier at an input of 3 volts.

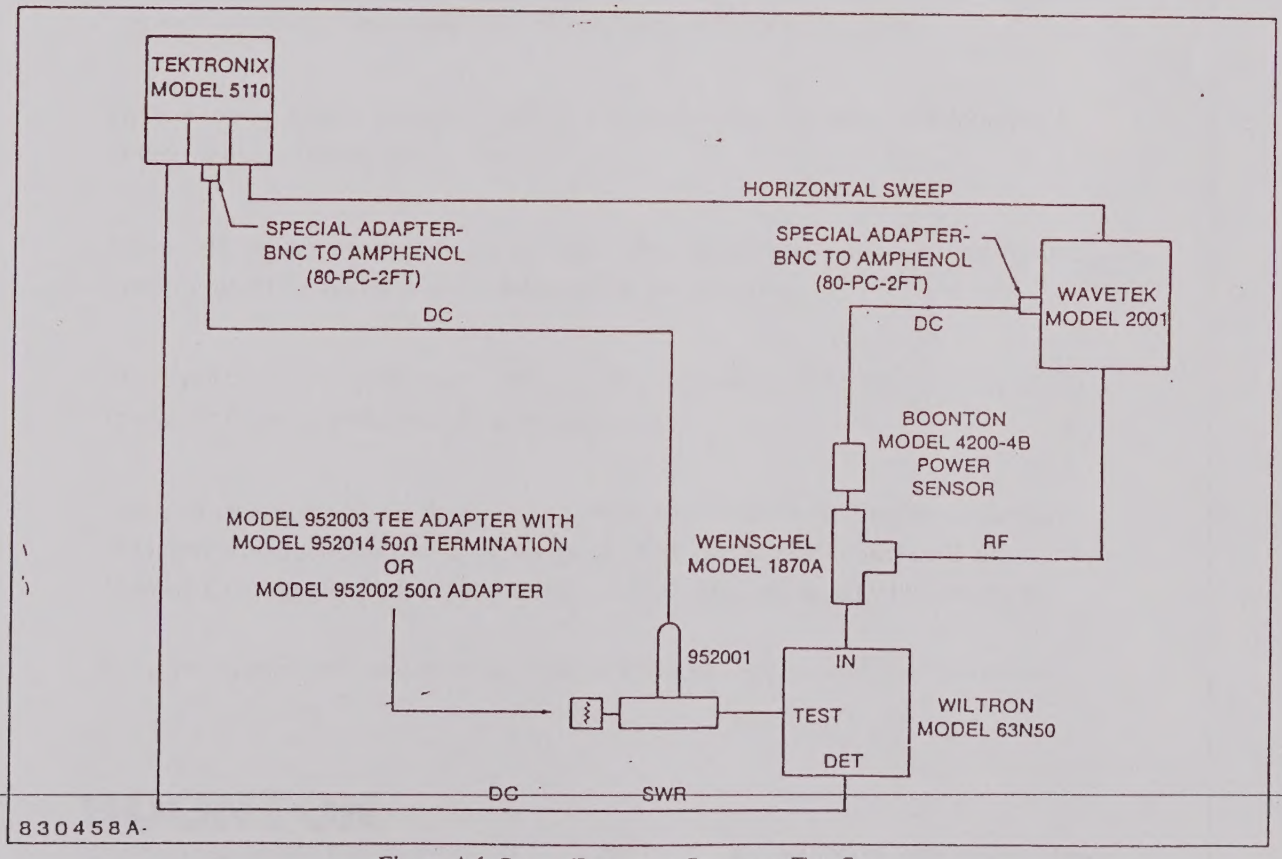


Figure 4-6 Swept Frequency Response Test Setup

WARRANTY

Boonton Electronics Corporation warrants its products to the original purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to active devices that have given normal service, to sealed assemblies which have been opened or to any item which has been repaired or altered without our authorization.

We will repair, or at our option, replace any of our products which are found to be defective under the terms of this warranty.

There will be no charge for parts, labor, or forward and return normal ground transportation during the first three months of this warranty.*

There will be no charge for parts, labor, or return normal ground transportation during the fourth through twelfth month of this warranty.*

Except for such repair or replacement, we will not be liable for any incidental damages or for any consequential damages, as those terms are defined in Section 2-715 of the Uniform Commercial Code, in connection with products covered by this warranty.

*For *overseas shipments,* there will be no charge for Air Freight during these specified time periods.

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